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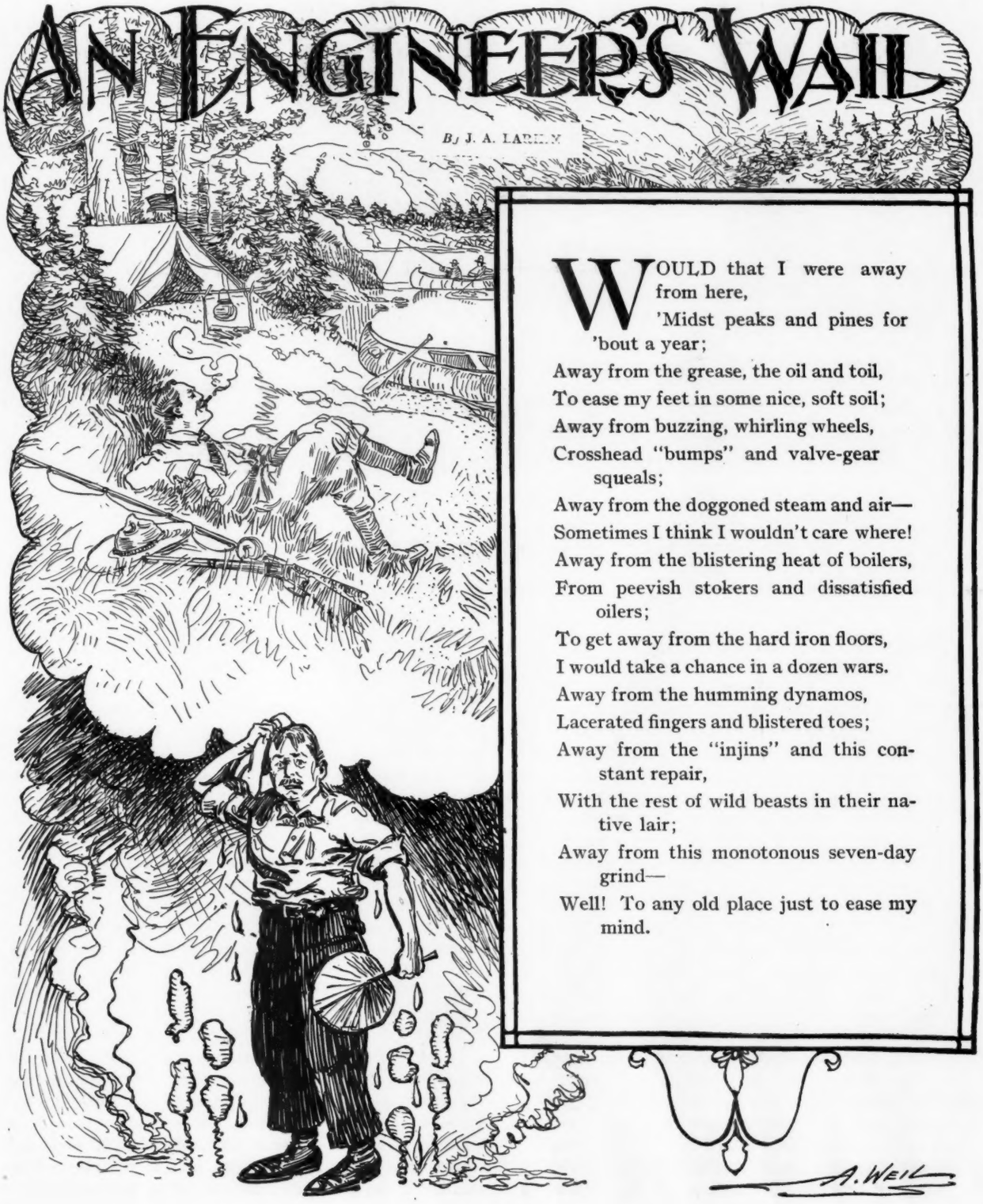
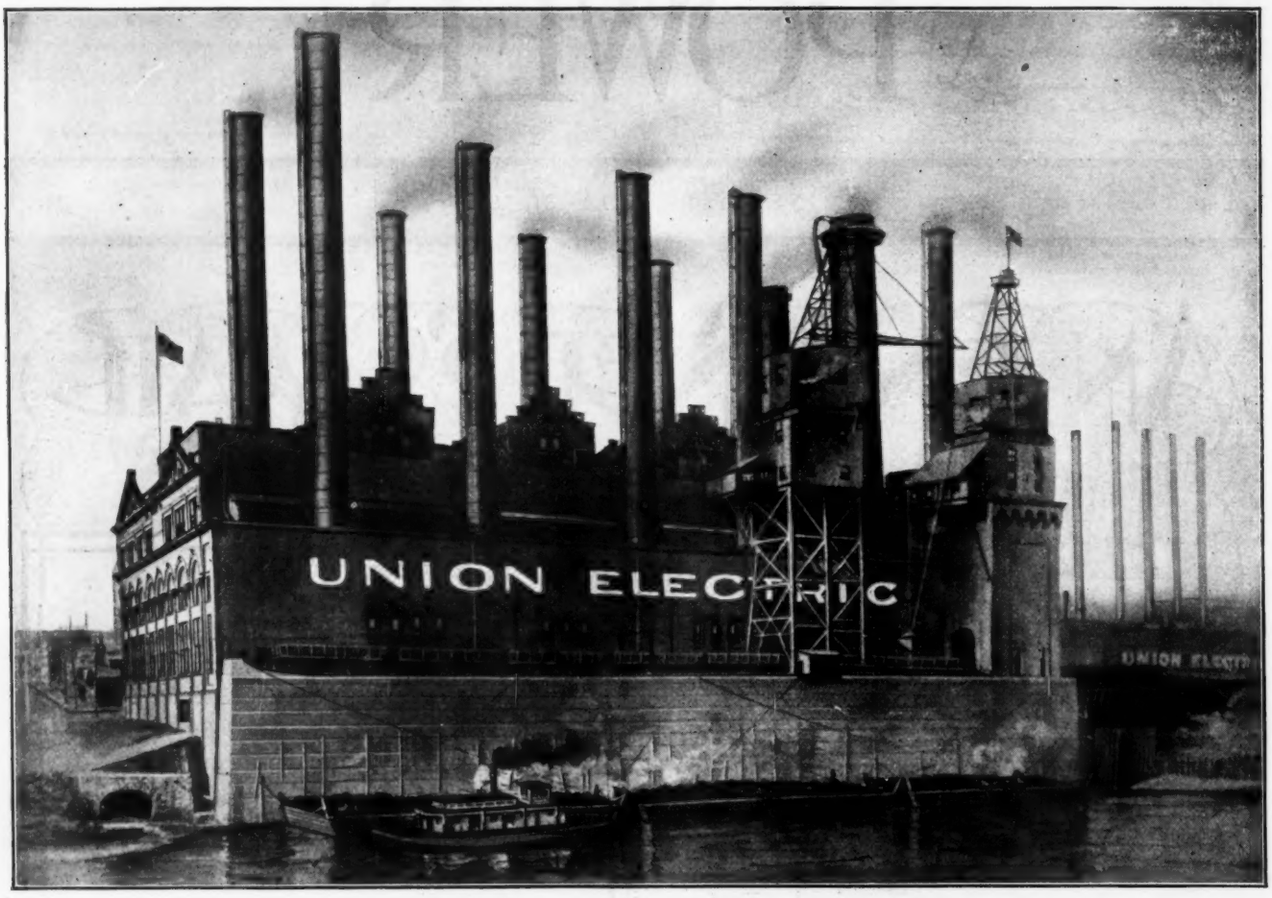

AN ENGINEER'S WAIL
By J. A. LABELLE
WOULD that I were away from here,
'Midst peaks and pines for 'bout a year;
Away from the grease, the oil and toil,
To ease my feet in some nice, soft soil;
Away from buzzing, whirling wheels,
Crosshead "bumps" and valve-gear squeals;
Away from the doggoned steam and air—
Sometimes I think I wouldn't care where!
Away from the blistering heat of boilers,
From peevish stokers and dissatisfied oilers;
To get away from the hard iron floors,
I would take a chance in a dozen wars.
Away from the humming dynamos,
Lacerated fingers and blistered toes;
Away from the "injins" and this constant repair,
With the rest of wild beasts in their native lair;
Away from this monotonous seven-day grind—
Well! To any old place just to ease my mind.
A. Weil



VIEW OF ASHLEY STREET STATION FROM THE RIVER

Ashley Street Station Remodeled

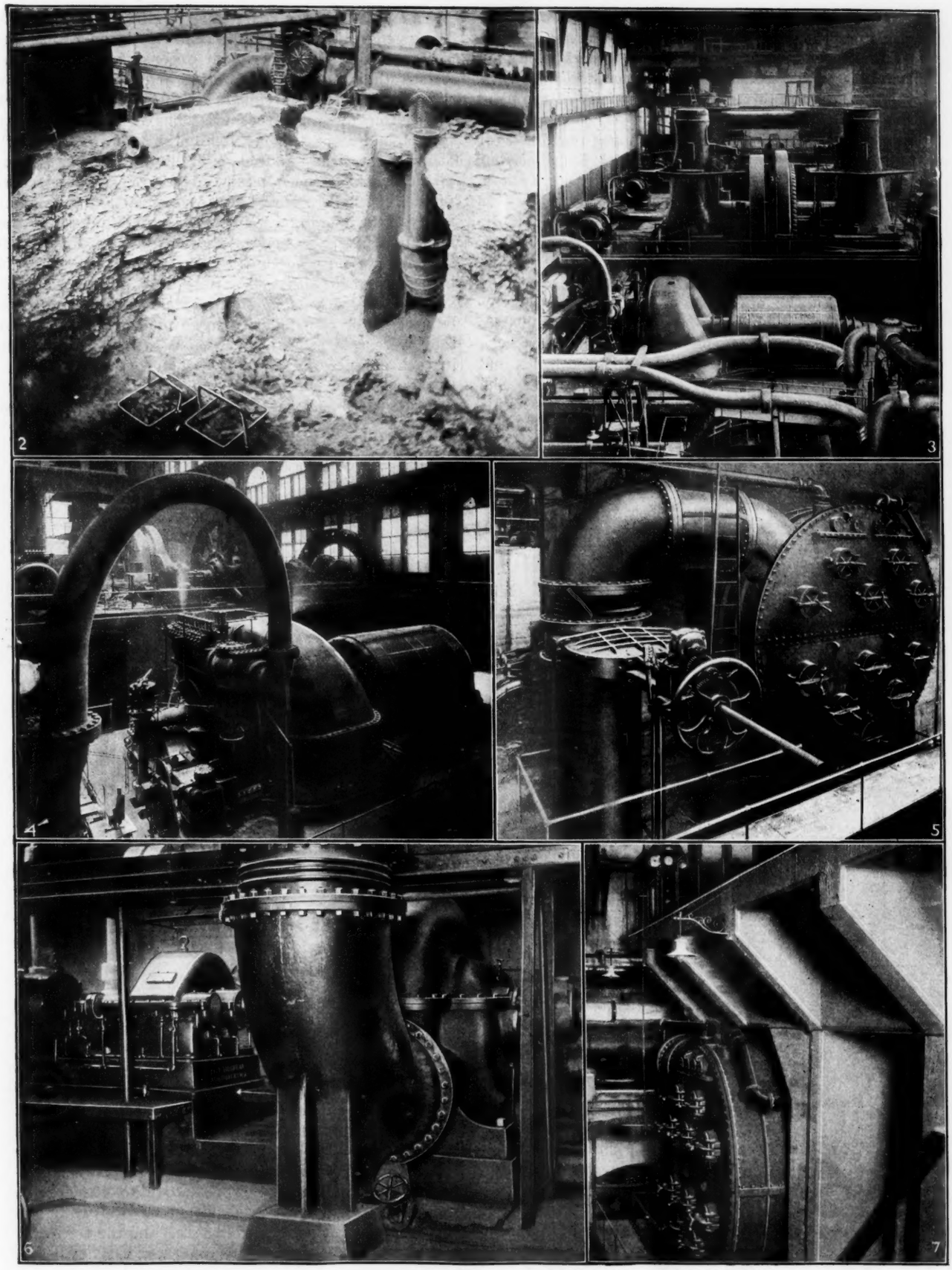
BY JOHN HUNTER
Chief Engineer, Union Electric Light and Power Co.

Story of re-equipping a plant designed for 12,000 kw. to an ultimate capacity of 116,000 kw.

THE rapid development in central-station equipment during the past fifteen years is shown to a marked degree in the central generating station of the Union Electric Light and Power Co., St. Louis, Mo. Ashley Street Station was originally designed and built in 1903 to deliver a maximum of 12,000 kw. of electrical energy. For this service there were installed five vertical cross-compound reciprocating engines driving 25-cycle generators. These units occupied practically the entire available space in the engine room and stood upon massive concrete foundations built upon bedrock lying beneath the plant. To furnish steam to these reciprocating units, the original installation included 28 Scotch marine boilers equipped with Jones underfeed stokers. The auxiliary equipment was in every way typical of the most improved design in machinery known at that time. Suffice it to say that none of the original equipment installed in this station is at present in operation.

Necessity for the rapid changes that began early in the life of the station was in the lack of sufficient generating capacity to meet the rapidly increasing demand from the city service. In 1905, after the station had been in operation only a little over a year, steam-turbine development had reached such a point that it was practicable to install four 5000-kw. generating units. A location was found in the engine room of sufficient area to receive the foundations for these units, and the machines when installed represented the maximum power on the least floor space in any of the generation stations in the country. To meet the steam demands of these units, it was necessary to rearrange the boiler room to receive 40 water-tube boilers with chain-grate stokers, the new boilers being installed on a second deck above the original installation of Scotch marine boilers. The chain-grate type of stoker, burning low-grade Illinois coal, was at that time found to be much better adapted to central-station work than the older type of internally fired boilers with underfeed stokers.

In 1908 the company's business had grown to such an extent that it was found necessary to further increase the station capacity by replacing the 5000-kw. turbines with 12,000-kw. units. The change was somewhat unique in that the steam and electrical ends only were replaced, the condensers and auxiliaries of the smaller turbines being made to serve the machines of



FIGS. 2 TO 7. INTERIOR VIEWS OF ASHLEY STREET STATION DURING AND AFTER REMODELING

Fig. 2—Excavating for 20,000-kw. turbine foundation. Fig. 3—New unit in place and dismantling of reciprocating engines. Fig. 4—20,000-kw. unit installed. Fig. 5—Wheeler 40,000-sq.ft. condenser. Fig. 6—50,000,000-gal. circulating pump. Fig. 7—Turbine foundation with condenser in place

higher capacity. With this increase in generating capacity it was necessary to replace 12 of the old Scotch marine boilers with more modern and highly efficient units, 12 B. & W. boilers being chosen for this work. The latest addition brought up the capacity of the plant to 64,000 kilowatts.

Further development in the station was restricted for a few years owing to the building of the hydro-electric power station on the Mississippi River at Keokuk, Iowa, from which the St. Louis electric company was able to obtain sufficient power to take care of the natural increases in load over a period of several years. In the fall of 1915, however, it was found necessary to again increase the generating capacity. The first step was to replace one of the 3000-kw. reciprocating engines, installing in the space occupied by it a 20,000-kw. horizontal Curtis turbine. The generator is a 4500-volt three-phase 60-cycle unit with four poles and rated at 20,000 kw. at 80 per cent. power factor. The speed is 1800 r.p.m. To supply steam to this new unit

To excavate in the heart of an engine room filled with large generating units and auxiliaries in operation was quite unusual in power-plant reconstruction and was a task that required great care and attention with a view to preventing accidents or shutdowns. The work of blasting away the rock was done in close proximity both to adjacent turbine foundations and to the rock foundation of the building wall, all of which was accomplished without the necessity of resorting to underpinning. The nature of the rock was such that it was not always possible to use dynamite at all points in the blasting, and it was often necessary to resort to cutting away certain portions by "bull pointing," the drills being driven for the most part by air machines.

The 3000-kw. vertical engines were of such size as to be useless for reinstallation in any modern station, and they were sold as scrap, of which there was 775 tons in each engine. For the installation of the 20,000-kw. turbo-generator there was removed 22 carloads of concrete and rock. This work was accomplished in three

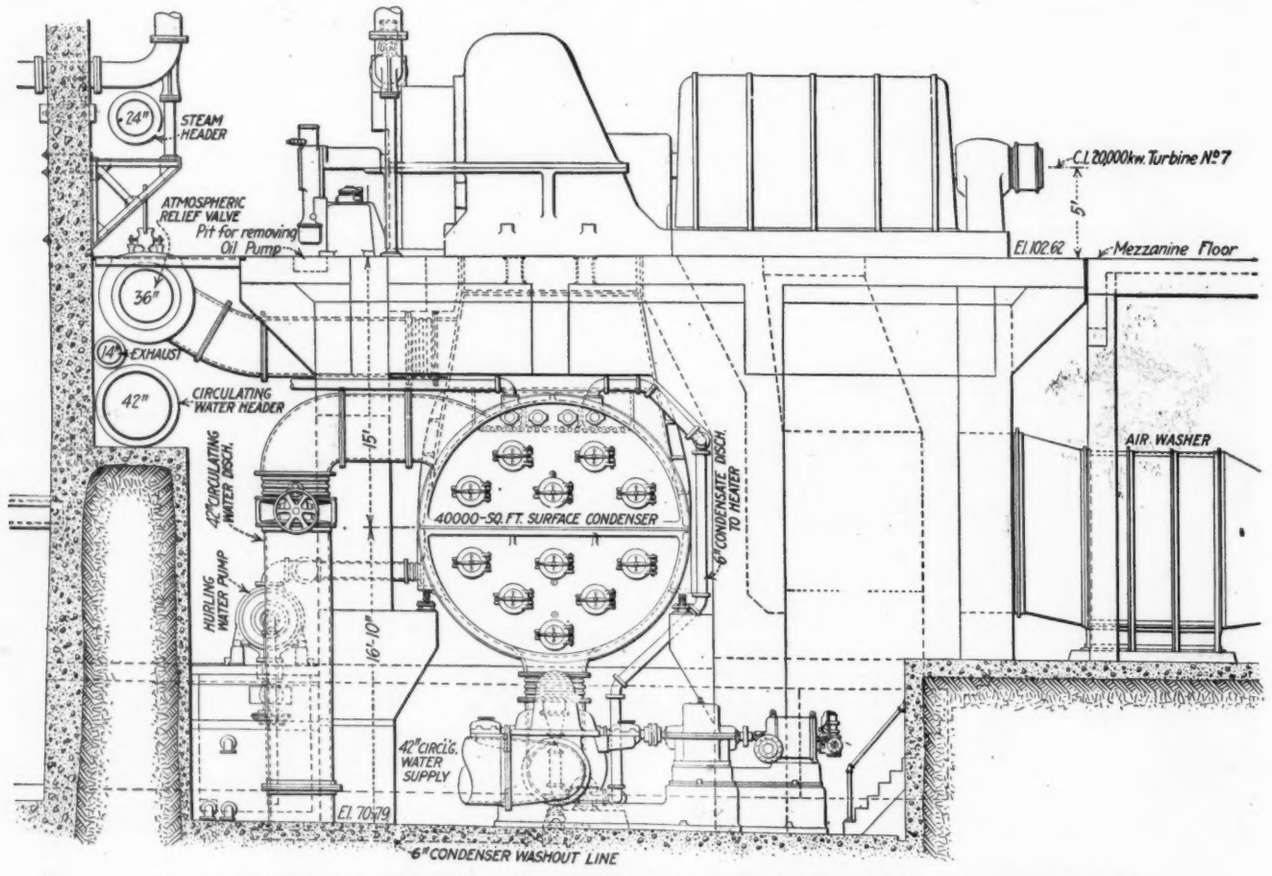


FIG. 8. ELEVATION SHOWING ARRANGEMENT OF TURBO-GENERATOR AND AUXILIARIES

the remainder of the old Scotch marine boilers were removed and 10 modern 558-hp. water-tube boilers were installed in their stead. This exchange of units is the first of a series of changes now being made, which are to bring up the ultimate capacity of the plant to 116,000 kilowatts.

As seen from the photographs, the depth of foundation of the new turbine is much greater than that of the old engine foundation, requiring the excavation of approximately 2100 cu.yd. of rock in addition to the blasting away of the engine foundation proper, occupying 900 cubic yards.

months. The building of the foundation for the new 20,000-kw. turbine was started on May 15, 1916, and completed about six weeks later. The foundation was built up of heavy concrete columns and girders, supporting both the turbine proper and the 40,000-sq.ft. condenser located immediately below, a total weight of about 400 tons. The reinforcing steel and the forms for the concrete were completely erected and in place before any pouring was done. The concrete was then poured continuously, requiring approximately three days' time.

The auxiliaries serving the turbine are of the most recent and approved design. The condenser, built by

the C. H. Wheeler Co., is of the two-pass type, circulating water being supplied by a Wheeler fifty-million gallon pump driven by a 300-hp. Kerr turbine. The vacuum pump is of the rotary "hurling water" type and successfully operates to within one inch of the barometer while carrying full load. This equipment is supplemented by an air washer which passes 50,000 cu.ft. of air per minute, humidifying, cleaning and cooling it before delivery to the ventilating duct of the generator. From the generator the air is discharged through an air duct 50 sq.ft. in section to the boiler room, which is adjacent to the forced-draft fans.

Condensation from the turbine, amounting to roughly 240,000 lb. per hour, is diverted in part before it passes through the reheater located on top of the condenser, and

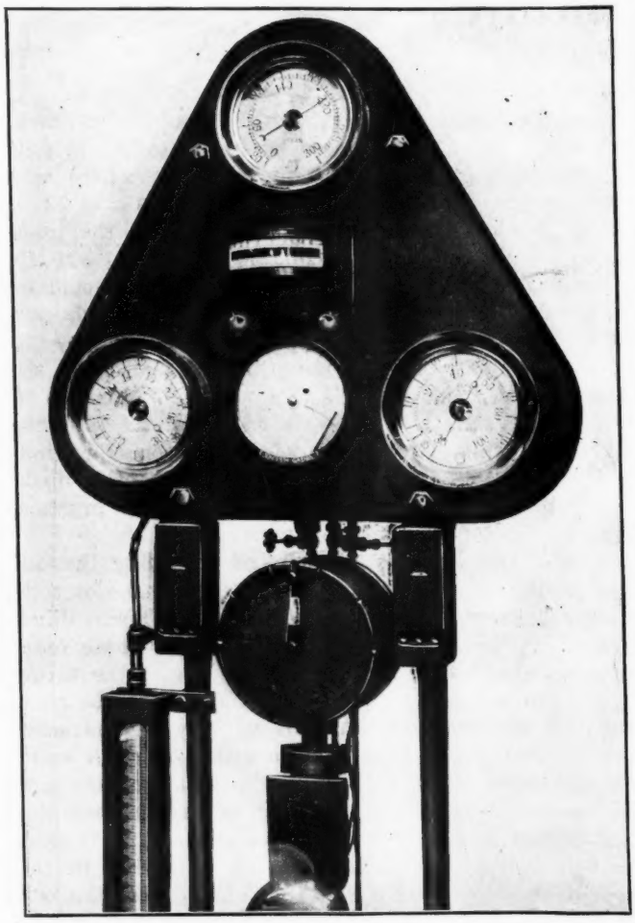


FIG. 9. GAGE BOARD, 20,000-KW. UNIT

passed through the cooling coils and bearing jackets of the turbine proper. In this way a generous supply of pure circulating water is available for cooling and the heat absorbed is further utilized, inasmuch as it is returned direct to the feed-water heaters.

Extensive tests on this turbine since it has been put in operation indicate that it is running well within the guarantees as to steam consumption and capacity, the former being 11½ lb. per kw.-hr. while operating at 1 in. absolute back pressure, 225 lb. steam pressure and 150 deg. of superheat.

The space occupied by two of the reciprocating engines has been utilized for the extension of the engine-house switch structure. Electrical equipment of the latest design and in keeping with the requirements of modern generating stations has been installed.

An interesting feature of the new installation is the turbine gage board. On the main panel are mounted the steam-pressure gages showing steam pressures on the

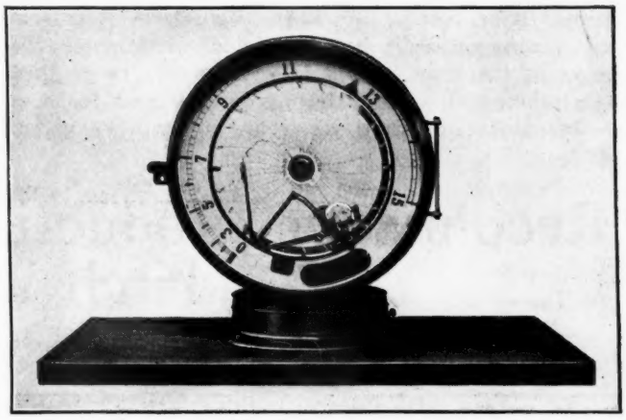


FIG. 10. RECORDING FLOW METER

main header and on the first stage of the turbine. At the left is the indicating vacuum gage with the recording instrument at the bottom center of the panel. Both these instruments show pressure on the condenser and are checked by means of a mercury column placed below the gage board. Vacuums are maintained on this condenser well within 1 in. of the barometer. The frequency indicator with synchronizing lamps is shown at the center of the board. Beneath the slate panel is mounted a ship signal arrangement for communication between the operating floor and the switchboard. The

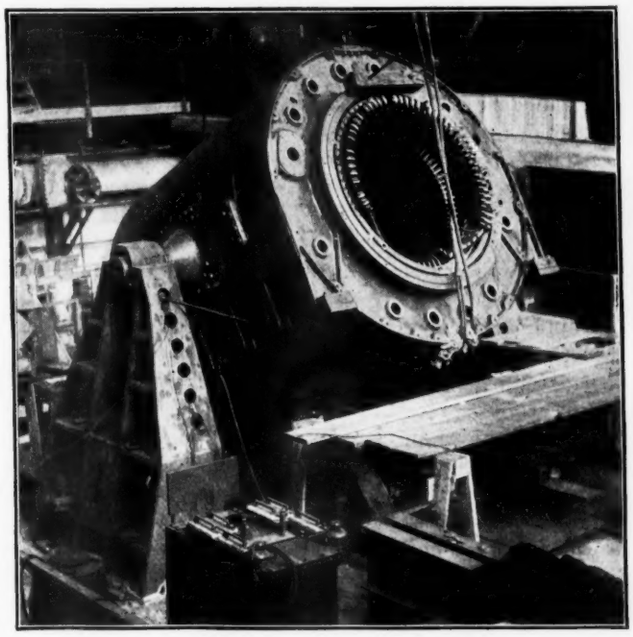


FIG. 11. SUPPORTING GENERATOR ON TRUNNIONS WHILE WINDING FIELD

alarm bell mounted beneath the ship signal calls the operator's attention to signals. Two sets of switches with button and pilot lights showing on each gage-board support are remote-control operating mechanisms for circulating-water inlet and discharge valves.

The circulating-water system formerly supplying cooling water to the condensers has been replaced by large tunnels with both intake and discharge from the river. The capacity of the new system is over 240,000,000 gal. per day. Traveling screens installed in the new tunnels to remove rubbish usually found in the Mississippi River revolve on 53-ft. centers, this unusual length being necessary because of wide variations in the stages of the river. At a later date a more detailed description, with views bringing out the main features of this new circulating water system, will be given. The boiler-house equipment will also require more extended treatment than is possible in this article.

Plans are now completed for the ultimate development of Ashley Street Station to include two additional 20,000-kw. turbines to be installed in the space occupied by the remaining two reciprocating-engine units. The new turbines will be duplicates of the unit already installed and will give a generating capacity of 116,000 kw. in a station originally designed for but 12,000 kw. The circulating water required per day will be twice that used by the entire city of St. Louis.

Reconnecting Induction Motors—Fractional-Pitch Windings

By A. M. DUDLEY
Designing Engineer, Westinghouse Electric and Manufacturing Co.

The reasons for winding the coils of an induction motor less than full pitch and the effects upon the operation of the machine are considered, also the distribution factor and phase insulation are touched upon.

THE effect of changes in frequency, phase, voltage or poles upon the performance of an induction motor and the necessary changes in the windings to preserve normal operation may be considered from the viewpoint of a change in voltage only and worked out by that method. By this is meant, for example, that a three-phase motor may be considered as a two-phase machine of a different voltage, in so far as the magnetic flux in the iron is concerned, also the heating, efficiency, torques, power factor, etc. Likewise a 25-cycle motor may be considered as a 60-cycle machine at a different voltage and operated accordingly.

A change in the number of poles can be looked upon as changing the speed of rotation of the magnetic field. With a given number of conductors this would at once affect the generated voltage or counter-electromotive force. It was explained in the first article of this series that the counter-e.m.f. was practically almost equal to the applied e.m.f., or line voltage. Hence it may be seen that even a change in the number of poles can be considered as a voltage change and the number of wires in the coils correspondingly changed so as to give the same performance under the new conditions.

Since all these changes can be considered as voltage changes and will be so considered in the articles to follow, it is necessary to investigate closely all the considerations that directly affect the voltage. The first one of these is the effect of winding the coils less than full pitch, or "chording" the coils, as it is most frequently called. The pitch, or span, is expressed in the number of the slots included between the two sides of the coil.

It is common knowledge that this pitch, or throw, must be somewhere near the quotient of the bore periphery of the core divided by the number of poles. For example, if the stator of a given motor had 72 slots and was wound for four poles, an individual coil would be expected to lie in slots 1 and 19 or thereabouts. The reason for this is that if there are four poles, the span of each coil must be somewhere near one-quarter of the bore periphery. In this case $72 \div 4 = 18$ slots, and $18 + 1 = 19$, hence the exact pitch for the coils of this winding would be 1 and 19. Similarly, a six-pole coil for the same core would lie in something like slots 1 and 13 and an eight-pole coil in slots 1 and 10. An examination of any induction motor wound in the usual way discloses the fact that the coils are seldom wound full pitch, as in Fig. 1, but always a few slots less, Fig. 2. It is the purpose of this article to discuss the reasons for winding the coils less than full pitch and the effect upon the voltage of the machine caused by this practice, which gives a fractional-pitch winding.[1]

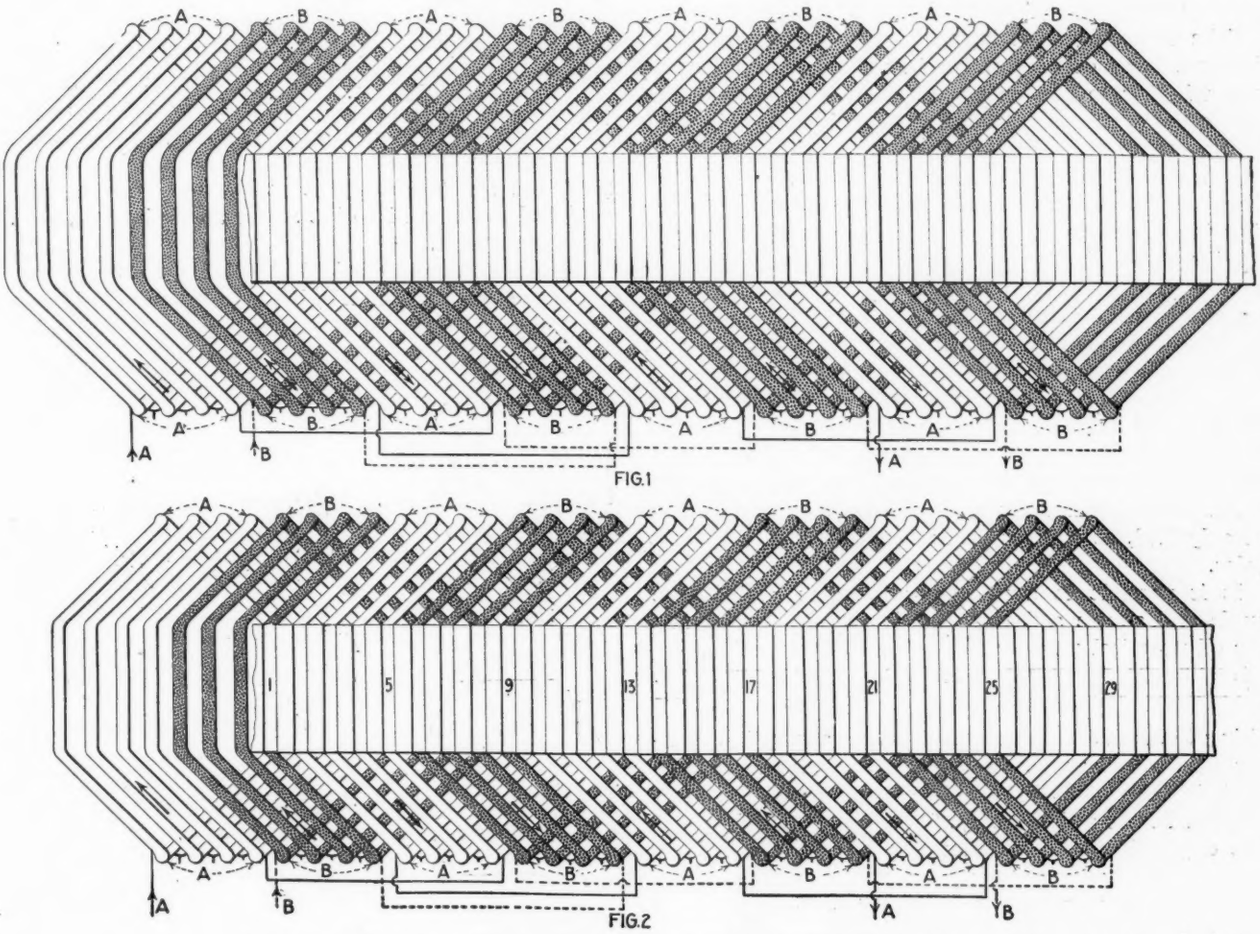
One of the immediate results of spreading the coil less than full pitch is to place in the same slot coils carrying currents of different phases. This is illustrated in Figs. 1 and 2, which show a two-phase four-pole winding placed in 32 slots. In Fig. 1 the throw of the coil is 1 and 9, or exact pitch, and it can be seen, that all the slots contain coils entirely of the same phase; that is, all slots contain either *A* or *B* coils. On the other hand, in Fig. 2, the throw of the coil is one less than full pitch, or it is chorded one slot and wound in slots 1 and 8. As a result, it is seen that in slots 1, 5, 9, 13, etc., the coil lying in the top of the slot is of a different phase from the coil in the bottom of the slot. At first thought this appears to be an interference, but it is really not so, since the values of the currents in the two phases at a given instant are different; and since one is increasing and the other decreasing, the effect on the magnetic circuit is due not only to the amount of current in the two coils, but also to their phase relation. Hence the result of chording is not to make the two phases interfere with each other in any way, but simply to have a tendency to reduce the number of turns in the coils, as will be described. That the resulting magnetic field which rotates is due to the interaction of all the phases in this way was mentioned in the Jan. 16 issue.

[1] A longer theoretical discussion of fractional-pitch windings is found in the "Transactions of the A. I. E. E.," Vol. XXVI, 1907, pp. 1485-1503, Messrs. Adams, Cabot and Irving; and Vol. XXVII, 1908, pp. 1077-85, Jens Bache-Wiig.

There are three main reasons for winding the coils less than full pitch: (1) The length of the mean turn is reduced; (2) it has the effect of changing the number of turns in the coil; (3) the over-all length of the winding parallel to the shaft is reduced, thus requiring less space in the end brackets which carry the bearings.

Discussing these effects in order, the reduction in the length of the mean turn accomplishes two results: First, less wire is required to form the coils, which is a slight economy; and second, the total resistance of the winding is reduced. This reduction in resistance, in turn, has two beneficial results—the one a reduction in copper loss with a corresponding gain in efficiency and the other a reduction in heating, since the heating is measured by the total losses that must be dissipated. The reduction in cost and the improvement in performance are both of a relatively small order, but they represent the minor details in which a nicely balanced design has an advantage over one more crude. The reason for the shortening of the mean turn can be seen from Fig. 3. The coil, *ABCDEF* is wound in slots 1 and 7 and the coil *AGHIJF* is wound in slots 1 and 6. It will be noted that the gain in length by the shorter coil is due not alone to the fact that the chord *AH* is shorter than *AC*, but also to the fact that the point *G* is considerably nearer the core than the point *B;* or in other words, the angle *AGH* is greater than *ABC.*[2]

The second effect of chording is that it acts in the same manner as changing the number of turns in series in the coil. Suppose, for example, that a designer of induction motors has made a calculation and finds that if six turns of wire are put in the coil there will be slightly too many turns for the best result, and if five turns are used there will be slightly too few. If there was not the recourse of chording the coil, it would be necessary to decide which was the lesser of the two evils, or else to change the number of slots. The latter might not be possible as it is desirable to have the total number of slots a multiple of the number of phases times the number of poles, and this could not be shifted in fine adjustments. However, it is possible to chord the coil and by the simple expedient of winding the coils one or more slots less than full pitch, the effect can be produced of putting 5½ or 5¾ turns in the coil, or in fact a very fine adjustment to give exactly the best possible combination. There would of course be six actual physical turns of wire in the coils, but their magnetic effect would be reduced by the chording to 5½ turns or whatever was desired.



FIGS. 1 AND 2. TWO-PHASE WINDINGS HAVING DIFFERENT COIL PITCH

Fig. 1—Two-phase, four-pole, 32-coil full-pitch winding. Fig. 2—Same as Fig. 1, except the coils are spread one slot less than full pitch

[2]See article in "Electric Journal," Vol. VIII, 94, by Gray E. Miller, on "Determining the Form of a Diamond Coil."

The effect of the turns in the coil varies as the sine of half of the angle in electrical degrees which the coil spans. To illustrate, if there are 72 slots in an eight-pole machine, the coils would spread exactly full pitch if they lay in slots 1 and 10; or in other words, if there were eight slots between the two slots in which the two sides of any coil were located. Such a coil would span 180 electrical degrees. One-half of 180 deg. is 90 deg., and the sine of 90 deg. is 1; therefore the effect of the turns in such a coil is 1, or maximum. Suppose, instead, the coil lies in slots 1 and 8. It would then span 140 deg. electrically, since $72 \div 8 = 9$ slots represents 180 deg; one slot therefore represents 20 deg. The sine of half of 140 deg., or 70 deg., is 0.94. Hence it follows that the effect of the turns in this coil is less than that of the full-pitch coil by the ratio of 0.094 to 1.

Changing Poles with Constant Throw

The foregoing is of interest in the present problem, because it is often possible in making alterations in the winding to change at the same time the span of the coils by one slot, more or less, by springing the coil mechanically, and so improve the performance of the machine under the new conditions. The point becomes of vital importance immediately when changing the number of poles without changing the throw of the coils. Referring again to the 72-slot motor, assume that the coils are wound in slots 1 and 8. For an eight-pole connection these coils will have an effect of 0.94, as explained. If the connections are changed for six poles, the effect is entirely different; $72 \div 6 = 12$ and $180 \div 12 = 15$, or each slot represents 15 electrical degrees. A throw of 1 and 8 covers seven complete slots, or $7 \times 15 = 105$ deg.; the sine of half of 105, or 52.5 deg. = 0.79, which means that when connected for six poles the coils have an effect of only 0.79, as against 0.94 when connected for eight poles.

It is possible to avoid using the sine of half the angle and secure a factor that is sufficiently accurate for all practical purposes by using the expression,

$$\sqrt{\frac{(Number\ of\ slots\ per\ pole)^2 - 2(number\ of\ slots\ dropped)^2}{(number\ of\ slots\ per\ pole)^2}}$$

Using the same eight-pole example as above, the number of slots per pole is $72 \div 8 = 9$, and the pole pitch is 1 and 10. When the coil is wound 1 and 8, it spans 7 slots and there are $9 - 7 = 2$ slots dropped. The expression then becomes

$$\sqrt{\frac{(9)^2 - 2(2^2)}{(9)^2}} = \sqrt{\frac{73}{81}} = 0.948$$

and similarly for the six-pole,

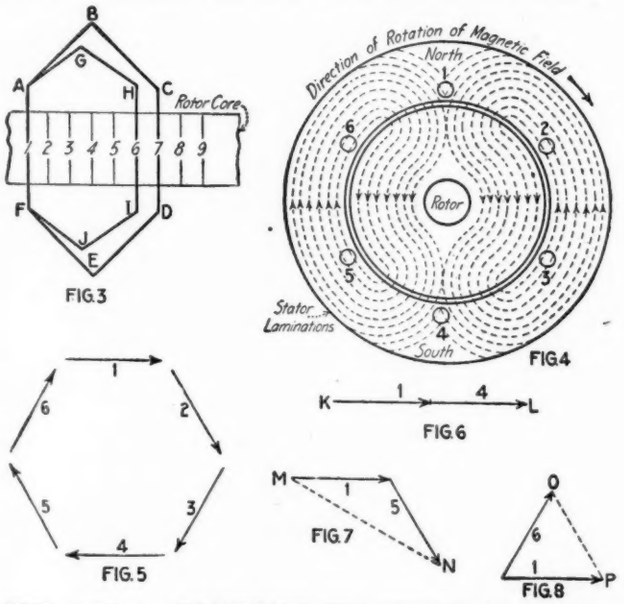
$$\sqrt{\frac{(12)^2 - 2(5)^2}{12^2}} = \sqrt{\frac{94}{144}} = 0.807$$

which agrees roughly with the other method.

A coil should in no case be chorded more than half of the pole pitch, as secondary disturbances of the magnetic field are occasioned by chording which become prohibitive at that point. The expression, "sine of half the angle spanned by the coil," is given the name "chord factor," and it should be considered in the work of reconnecting. For example, if the poles are changed from 8 to 6, as in the example given, and the chord factor changes from 0.94 to 0.79, the new line voltage should be $0.79 \div 0.94$ times the old, neglecting the effect of other changes that are being made. If nothing else was undergoing change and the normal voltage was 440 in the first place, it should be $440 \times \frac{0.79}{0.94} = 370$ after the change is made; or, expressing it another way, if it was still operated at 440 volts after the change, the motor should be thought of as operating at about 18 per cent. over voltage.

Since the foregoing is one of the important points in induction-motor winding, it is worth while to consider carefully how this effect is produced. It could be stated briefly by saying that the two sides of the coil, which of course are in series, are not strictly in phase with each other. But this can be seen more clearly from diagrams. Suppose, for example, that a two-pole motor is considered and that a cross-section is taken through the core and windings in a plane at right angles to the shaft, as shown in Fig. 4. The dotted parallel lines in the peculiar twin pattern represent the lines of force, or magnetism of the rotating magnetic field, which is rotating in a clockwise direction, as shown by the arrow outside. The small arrows on the lines of flux indicate the magnetism coming from the stator north pole at the top into the rotor core and out again into the stator at the bottom, forming a south pole.

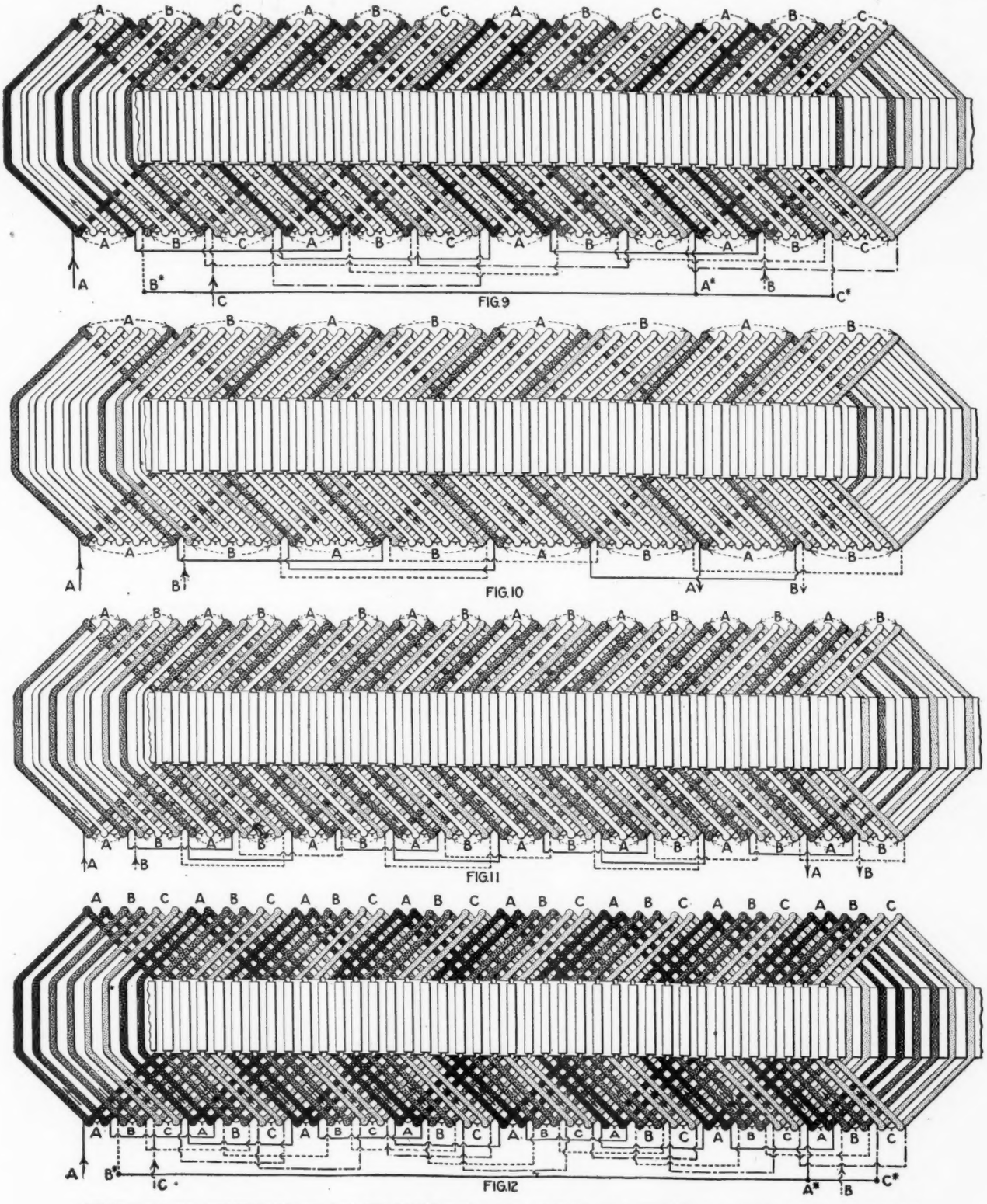
Of course this magnetic field is being set up by polyphase alternating currents, but it need only be thought



FIGS. 3 TO 8. ILLUSTRATE THE EFFECT OF WINDING THE COILS LESS THAN FULL PITCH

of as shown in the figure and as if excited by direct current. The six small circles, in the stator and near the bore, numbered 1 to 6, represent the conductors of the stator winding. Consider that these six conductors constitute the complete winding. As the magnetic field swings around in a clockwise direction, it cuts these six conductors because without doing so it cannot get from the stator into the rotor and back and at the same time rotate. As the conductors cut this field, each one generates a voltage which in value and direction may be represented by the arrows or vectors of Fig. 5.

The reason these voltages are shown in a hexagon is because they are not all generated at the same time, but in a succession. For example, the north pole sweeps a hexagon which finally closes on itself, as shown in Fig. 5. The reason the arrows for conductors No. 1 and No. 4 are shown in the same direction is because



FIGS 9 TO 12. POSITION OF PHASE COILS FOR DIFFERENT GROUPINGS OF THE SAME WINDING

Fig. 9—Three-phase, four-pole. Fig. 10—Two-phase, four-pole. Fig. 11—Two-phase, six-pole. Fig. 12—Three-phase, six-pole

by conductor No. 1 and a fraction of a second later past No. 2 and then past No. 3 and so on around to No. 6, and this can be represented by the sides of the north pole is sweeping past No. 1 to the right at the same instant that the south pole is sweeping past No. 4 to the left, so that the voltages in these two

conductors are in the same direction at the same instant. Similarly, Nos. 2 and 5, and Nos. 3 and 6 are alike in pairs. Suppose now that No. 1 and No. 4 had their ends connected together both at the front and the back of the machine so that they formed a short-circuited turn. The voltage then which would be effective in forcing current around this short-circuit would be that generated in No. 1 plus that in No. 4 and may be represented by line No. 1 plus No. 4, or *KL*, shown in Fig. 6. *KL* then would represent the voltage of a coil wound exactly full pitch or from the center of a north pole to the center of a south pole.

Suppose, instead of No. 1 and No. 4, that No. 1 and No. 5 had their ends connected so as to form a short-circuited turn. The voltage which would be effective in forcing current around through this short-circuit would be *MN*, shown in Fig. 7, which it will be seen is somewhat less than *KL* in Fig. 6. The arrow *MN* is made by adding 1 and 5 which in themselves are just as long as 1 and 4, but instead of lying in a straight line they are at an angle to each other. This angle shows what is meant by the two sides of the coil being out of phase with each other, or still another way to say it would be that the magnetic field is not working on No. 1 and No. 5 in exactly the same way at the same instant as it was on No. 1 and No. 4. Therefore, when No. 1 and No. 5 are short-circuited giving the voltage *MN*, they represent a coil chorded to two-thirds of full pitch, or they have the effect instead of being two conductors in series, of being only 2×0.866 conductors, or 1.73 conductors. This is because two-thirds pitch would be $\frac{2}{3} \times 180$ deg. $= 120$ deg. and the sine (0.5 of 120 deg.) $=$ sine 60 deg. $= 0.866$.

In the same way conductors No. 1 and No. 6 could be joined in series to form a short-circuited turn, and the voltage of such a turn would be represented by *OP* in Fig. 8, which is made up of No. 1 and No. 6, which are at an angle of 60 deg. with each other. In this case, instead of having the effect of two conductors in series so far as voltage generation is concerned, the effect will be that of only one, since 1 and 6 represent one-third pitch, and $\frac{1}{3}$ of 180 deg. $= 60$ deg. and the sine (0.5 of 60 deg.) $=$ sine 30 deg. $= 0.5$. Therefore $2 \times 0.5 = 1$. Of course 6 slots per pole is a small number and it can be seen that with 12 or 15 slots per pole at his disposal the designer can chord to get almost any value required.

Effect of Chording

It will be noted that in this graphic explanation the conductors were spoken of only as generating counter-e.m.f., as explained in the first article and never as setting up the field. However, it should be understood that in the magnetizing function of the winding, also, the chording produces the same effect as explained here by means of the generator idea.

The third effect of chording has been mentioned as shortening the coils axially. This is very useful, especially in the case of two-pole and four-pole machines where the coils, if made full pitch, would protrude so far at each end as to require special end brackets. These long end brackets in turn would spread the bearings farther apart and make necessary a larger shaft to keep down the shaft deflection. Hence it is of prime importance to shorten up on the coil ends in this manner. Also, the end windings are mechanically stiffer. There are other effects of chording known to the designer, which are desirable. These are, for example, a reduction in the leakage reactance, thereby giving better torques and possibly better power factor and efficiency. Also, it is very beneficial in reducing magnetic noise to employ chording, depending on the combinations of slot numbers, so that, taken all in all, chording is one of the prime features in studying the effect of winding changes upon the performance of a machine.

Distribution Factor Less Important

Another winding factor that acts in a similar manner to the chord factor just discussed is the one known as distribution factor. This is not subject to control as is the chording and is relatively much less important, but should be mentioned in passing, as its neglect might occasion trouble if a combination was employed which otherwise was on the ragged edge of failure. This distribution factor has to do with the fact that the coils in one phase of a two-phase motor are spread over half of the face of a pair of poles and in a three-phase motor are spread over one-third of the face of a pair of poles. This factor varies a trifle with the number of slots per phase and pole, but a fair value for average two-phase windings is 0.905, which is about the ratio of one side of a square inscribed in a circle to one-fourth of the circumference. For a three-phase machine a fair average value is 0.955, which is practically the ratio of one side of a hexagon inscribed in a circle to one-sixth the circumference, or $3 \div 3.14$.

Ordinarily this factor is not troublesome and if forgotten in changing from two- to three-phase, or vice versa, would not cause any great disturbance. However, in dealing with special machines—as for example, motors wound for two sets of poles—the distribution factor may be more important than the other factors. In such a case the two-phase distribution factor may be as low as 0.707 and the three-phase as 0.866 because the coils for a four-pole motor, for example, are spread over the pole face of an eight-pole. Mention is made of this fact in connection with Fig. 5 of the fifth article of this series (*Power*, May 22, p. 690).

Phase Insulation Important

Another general factor is that of "phase insulation." It is the practice of many manufacturers to put heavier insulation on the coils at the ends of the polar groups which are mechanically adjacent to one another and which are also subjected to the voltage between phases, which may be the maximum voltage between supply lines. Such coils are drawn in heavy lines in Fig. 2 of the fourth article (*Power*, Apr. 17, p. 520). By rearranging this diagram for two-phase it appears at once that both the number and location of these so-called "phase-coils" are changed, and in changing the number of poles, the number and location of the phase-coils must also be changed. In fact, whatever reconnection is attempted, the phase coils should be checked and rearranged, since this is comparatively easy and adds considerably to the protection of the machine from breakdowns of insulation.

To illustrate the manner in which the phase coils should be rearranged when changing phases or poles, Figs. 9 to 12 are shown. All four of these figures show the same winding in 48 slots and with a coil throw of 1 and 9. In Fig. 9 the phase coils are arranged for three-phase four-poles, in Fig. 10 for two-phase four-poles, in Fig. 11 for two-phase eight-poles and in Fig. 12 for three-phase eight-poles. It will be noted that since the throw of the coils remains unchanged, it represents a chord factor corresponding to two-thirds pitch, or 120 deg. for the four-pole winding (since 8 slots = $\frac{2}{3}$ of 12) and a chord factor corresponding to one and one-third or 240 deg. for the eight-pole winding (since 8 slots = $1\frac{1}{3}$ of 6). Since the chord factor is equal to the sine of $\frac{1}{2}$ the spread angle and since the sine of 120 deg. = the sine of 60 deg. = 0.866, the effect of the underchording on the four-pole winding is exactly the same as the effect of the overchording on the eight-pole winding.

In all four diagrams the coils having heavier insulation than the others are shown shaded, the different degrees of shading representing the coil having additional insulation in the different phases. In Fig. 9 there are 12 pole-phase groups of four coils each. The two outside coils of each group have heavier insulation, as indicated; this will give 24 phase coils, or one-half the winding is phase coils. The winding Fig. 10 has eight pole-phase groups, with 16 phase coils, or one-third of the total winding is phase coils. In Fig. 11 the winding has 16 pole-phase groups, making it necessary that there be 32 phase coils. The arrangement in Fig. 12 gives 24 pole-phase groups of only two coils per group, hence all the coils must be phase coils with increased insulation.

Tom Hunter, Hoisting Engineer

By WARREN O. ROGERS

We start for the copper country, and on the way Hunter improves the time by telling of some pumping stunts that have been used at the iron mines such as we had just left. One device, which Hunter called a "Sea Lion," is operated with compressed air and automatically elevates water as long as the air pressure is supplied.

AS ARRANGED, we left the iron country for the copper region on the first train after we had decided to move on. We had the smoking compartment to ourselves, and Hunter, after getting his pipe lighted to his satisfaction, began to talk as usual about mining methods.

"They pull off some interesting stunts at some of these mines, and if one could get a line on them, they would make a mighty interesting book and be of considerable value to the men. I remember an instance in one of the iron mines where a pocket of water was encountered that was of such volume that the mine pump and lower workings were flooded."

"How do they get the water out in such a case? It must be quite a job."

"A sinking pump can be used to advantage. Of course the mine pump is generally operated by steam, and as the steam pipe to the pump would be submerged, the steam would condense and so prevent the pump from being used to free the mine of water. When a mine is flooded, one way to free it is to let down a sinking pump."

"What in the name of Moses is a sinking pump?"

"Well, it is made vertical and is direct-acting with a single plunger. It is fitted with one or more eyebolts in the upper part of the pump so that it can be hung vertically in the shaft and raised or lowered as conditions require. In a shallow mine the pump will have no difficulty with the head against which it pumps, but as the water in the mine diminishes and the pump is lowered, the head becomes greater. In the case I have in mind, the sinking pump was operated with air at 100-lb. pressure. With an increased head the pump was just able to hold the water level, but could make no gain. Before sending for another pump, someone suggested tapping the exhaust into the water discharge line just above the pump. This was done, and the water was under control in two days." (See Fig. 1.)

"What was the idea of exhausting the air into the water discharge pipe? Trying to make an air-lift system out of it?"

"Exactly. The water and air would be in alternate layers in the discharge pipe, the same as in an air lift. When the air from the pump was discharged into the water pipe, it expanded as it moved toward the surface. The space occupied by the air reduced the feet of water head in the discharge pipe, and of course reduced the pressure against which the pump worked. The back pressure on the pump was increased with such an arrangement and approximately equaled the sum of the height of the different layers of water in the discharge pipe, divided by two.

"It don't take much to put a pump out of business sometimes. I remember once where a sinking pump was being used, that after it had been working awhile it refused to throw water, and it gave them a run for their money before they found out where the trouble was. The pump was taken apart several times and everything but the right thing examined, and although the pump would run all right it would not throw any water. You see the suction pipe of a sinking pump is usually a piece of rubber hose about 12 ft. long. Nobody thought to examine that until an old fellow who had been around mines all his life came along and was told of the trouble. He immediately suggested the suction hose as the seat of the trouble, and an examination showed that he was right."

"What was the matter with the hose? Have a hole in it?" I asked, at the same time watching the natives lounging about the platform at the station where we had stopped.

"A hole had nothing to do with it at all. You know that the general run of rubber hose is made up of alternate layers of rubber and canvas. Well, this piece

was made that way, and the inside layer of rubber had for some reason or other separated from the rest of the hose for some little distance, and just as soon as the pump was started, this loose rubber would collapse and prevent water from getting to the pump. This drawing will make clear just what occurred," and Hunter sketched Fig. 2.

Just then the train started with a jolt, and when Hunter had regained his balance, he said: "That makes me think of a water elevator that was operated some years ago. The boys called it the 'Sea Lion,' and it did fairly good work. I guess that I had better make a sketch so as to show you how it was made and how it operated." Fig. 3 is something like Hunter's drawing. "It consisted of a body inside of which was a needle valve attached to the air-supply pipe. The other end of the valve connected with a plugged pipe, because the idea was to have the air supply enter the valve at the supply end and escape past the needle

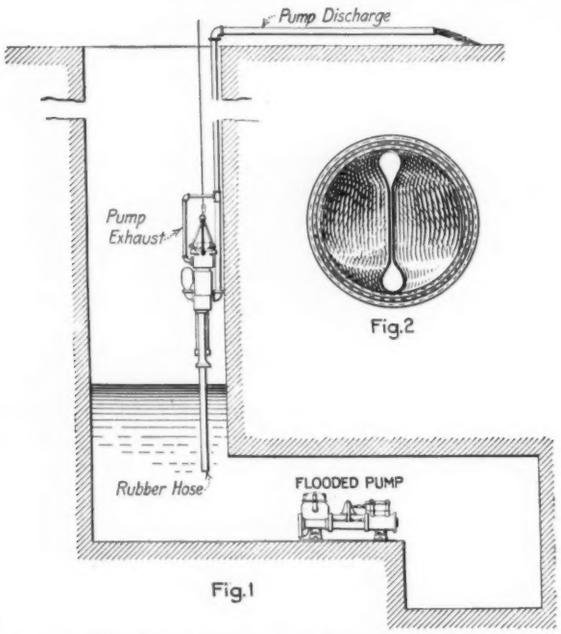


FIG. 1. SINKING PUMP WITH EXHAUST PIPED TO DISCHARGE PIPE. FIG. 2. COLLAPSED SUCTION HOSE

valve to the chamber, the plugged pipe being used merely as a support. On the valve stem there was a bucket float that engaged with a flat valve on the valve stem as the water in the body of the lifter rose. The needle valve was closed by the weighted arm on top of the casing, the two weights being used to get a semibalanced effect. On one side near the bottom was the discharge outlet, and the intake opening was in the center of the bottom. The opening was fitted with a flat valve."

"How does the thing work," I asked, as Hunter handed his sketch to me.

"It's as plain as that cigar in your mouth," answered Hunter. "The whole thing is submerged in the water to be handled. With the body empty, water will flow in through the bottom valve. As soon as the water reaches the float, it begins to rise with the valve stem until it strikes the top flat valve, just above. This movement forces the flat valve against a seat and prevents air leakage out around the valve stem. When the needle valve is lifted from its seat, air at about 45-lb. pressure is admitted to the water chamber and this air pressure forces the water out through the discharge pipe. When the discharge period is over, the float drops and the weight lever closes the needle valve. Water then flows in through the inlet pipe,

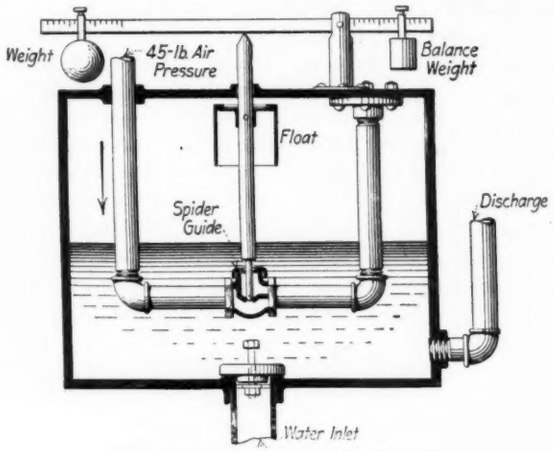


FIG. 3. SECTION OF SEA LION

and the same thing is repeated. As it is automatic in action, it will handle water as long as air is supplied, if the lift is not too great. With 45-lb. air pressure, water can be discharged to a height of about 150 feet."

"Don't the thing give trouble? Almost everything does you know."

"Of course it does," answered Hunter. "For instance, if the lift is too high the water will break; that is, slugs of air will be forced up through the water without lifting the water in the discharge pipe. Then again, if the compressor that furnishes air is shut down

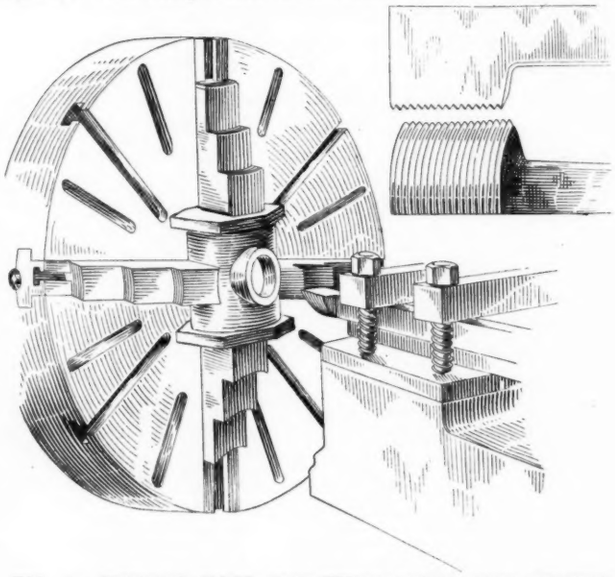


FIG. 4. SPECIAL TOOL FOR THREADING PIPE FITTINGS

just after the lifter has partly discharged, there will be two discharge loads to be handled. I don't think there are many of those lifters used now."

"I suppose steam pumps are best, but that would be a handy thing to use under some conditions.

"Hunter, I saw a stunt in one of the shops the other day that appealed to me, and that was a tool

for threading a lot of special tee fittings. The boss told me that they used a large number of them in the mines and that they did their own machine work on them. The tee was put in a chuck of the face-plate type, and the side outlet hole was bored to the proper size. Then, instead of chasing a thread in the fitting, which generally requires several operations of the ordinary thread-cutting tool, they had rigged up a special tool that cut the thread in one operation.

"This tool was made something like an ordinary inside threading tool, with the exception that the cutting end was shaped about the same as a common tap would look if it were cut endwise into four sections and three of them were removed, leaving the fourth to do the threading. This tool had 17 threads, and it was tapered so that the threads on the outside end of the hole would be larger than the inside end so as to make a tight fit when a pipe was screwed in.

"As you were talking to that old fellow, you didn't pay much attention to that piece of work, and this sketch," showing Fig. 4, "will make the whole clear. The shank end of the tool was held in the tool post of the lathe, and it was fed into the casting the same as an ordinary tool is fed for thread cutting. When the tool required sharpening, it was ground on the top edge. It is about the best time saver that I have seen in a long time."

At this stage of the talk the train began to slow down, and it was evident that we were nearing Houghton, where we expected to stop for about a week. When the train pulled in, we went to the hotel, and while Hunter hung around the house, I scouted about for a map of the county so as to easily locate the various mines. Incidentally, arrangements were made to visit many of them so that there would be no hitch when we did arrive at the shafts. As the next day was Sunday, we slept loud and long.

Leeds & Northrup Optical Pyrometer

For the measurement of temperatures above, say, 1400 deg. F., only two methods have been found practicable for works service. One is based on the thermocouple, used either with the milli-voltmeter or with the more accurate and reliable potentiometer. The other method is based on the laws of radiation and includes both the radiation pyrometer, which would be more properly named the "total radiation" pyrometer, and the optical pyrometer, which utilizes only that radiant energy visible to the human eye.

For many services the inexpensive and sturdy base-metal couple may be used for accurate measurements up to 2000 deg. F., with satisfaction; the more fragile and expensive platinum couple may be used up to 2800 deg. F., but the thermocouple, like thermometers in general, must assume the temperature of the hot object by convection, conduction, radiation or all combined. In many industries the temperatures used are far above the range of thermocouples.

Measurements by radiation can be carried out at a distance, once the laws connecting temperature of radiating body and intensity of radiation have been determined, and the radiation receiving and measuring part need not be heated to the temperature of the radiating body, nor even to anywhere near the temperature. Pyrometers utilizing radiation are divided into two classes—those which measure as heat energy the total radiation falling upon the receiving part of the instrument, and those, known as optical pyrometers, which are based on the fact that the luminous radiation

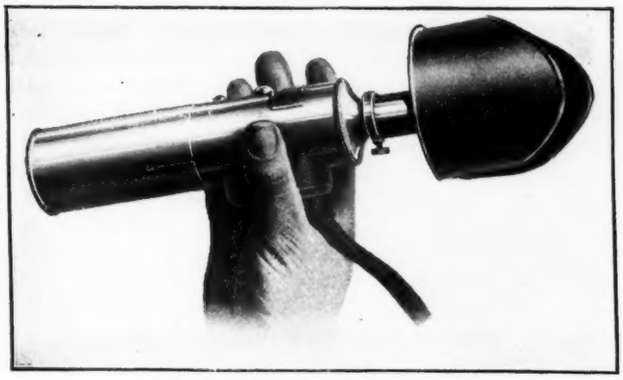


FIG. 1. OPTICAL PYROMETER

or light varies in a definite manner as the temperature of the hot body changes.

The greatest success has been attained by separating out one kind or wave length of radiation, usually that which excites the sensation of red, and comparing the intensity of this one-color light with the intensity of the light of the same color emitted by a standard source of light. The eye is very sensitive when comparing the brightness of two surfaces when one is superposed upon the other, and after having arranged to have light from the hot body and light from the standard of comparison viewed in this relation, they can be made equal, either by varying the amount of light received from the incandescent object or by varying the intensity of the standard of comparison.

The latter method—that is, variation of the intensity of the standard of comparison—is used by the United States Bureau of Standards. The Leeds & Northrup Co., of Philadelphia, working under the fundamental Morse patents, has lately developed this type of optical pyrometer. The instrument, which is illustrated in Fig. 1, is suitable for measuring from dull red (about 1100 deg. F.) up to the highest known temperature.

The manner in which the luminous radiation from the

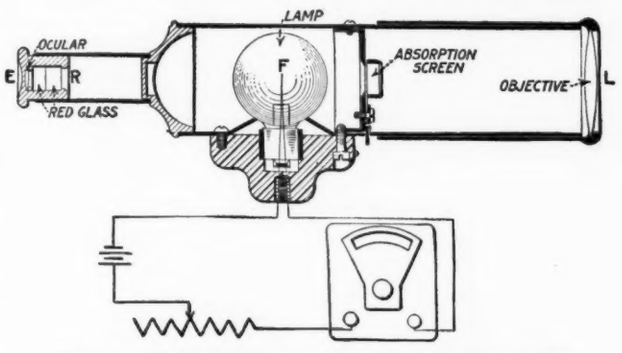


FIG. 2. SECTION THROUGH PYROMETER, ALSO ELECTRICAL CIRCUIT

hot body is balanced against that from a standardized source will be understood by reference to Fig. 2. *L* is a lens by which rays from the hot body are brought to a focus in the plane *F*, where there is located a tungsten-lamp filament. By means of the eyepiece *E*,

the observer views the incandescent filament, which appears to lie upon the image, just as the cross-hairs in a surveyor's telescope appear upon the distant object looked at. By means of a rheostat in a case slung about the neck, the case also containing a storage battery and milliammeter, the current through the lamp is adjusted until the brightness of the filament is just equal to the brightness of the image produced by the lens; that is, so that the filament blends with, or becomes indistinguishable upon, the background formed by the hot object. The observer then notes the reading of the milliammeter, which may be provided either with a special scale to read in degrees of temperature, or the temperature corresponding to the current may be read from a calibration curve supplied with the instrument.

The adjustment is made with great accuracy and certainty, as the effect of radiation upon the eye varies some 20 times faster than does the temperature at 1300 deg. F., and some 14 times faster at 3400 deg. F., while as already stated, the eye is very keen in distinguishing differences in brightness between superposed objects.

Red Glass Used

At high temperatures the light emitted by both the hot body and the filament would become dazzling and comparison would be difficult. For this reason a red glass is placed in the eyepiece at *R*, which has the further advantage that light of only one color then reaches the eye and no difficulty is introduced by lack of color identity between the light emitted by the hot body and that emitted by the filament. The intensity of light radiation of any one color increases progressively in a definite manner as the temperature of the radiating body rises, and nothing is therefore lost by eliminating all other light from the comparison. As only brightness, not color, of light is matched, inability to distinguish colors and color-blindness do not interfere with the use of the instrument. In fact, in the region of temperatures used for hardening steel, for example, different observers using this instrument agree in their readings within 6 deg. Fahrenheit.

The brightness of the image of the hot body produced by the lens *L* is almost constant, irrespective of the distance from the hot body, although the size of the image varies with the distance. Since it is the brightness of the image and not the total radiation received through the lens that is measured, it is possible to measure the temperature of a small body or of a body at a distance equally as well as that of a large body or one near at hand.

Screen Reduces Light from Hot Body

In observing bodies at very high temperatures, as 2500 to 10,000 deg. F., the light received through the lens would be too blinding for direct observation, even through the red glass of the eyepiece, and the intensity of the image might also become greater than that at which it is practicable to burn the tungsten filament, so that a balance would become impossible. Therefore, a screen is used, placed between the lens and the image so that it reduces the light from the hot body, but not that from the filament.

The screen used for cutting off part of the radiation from very hot bodies can be thrown into or out of the field of view by means of a milled disk projecting through an opening in the tube of the instrument. With the absorbing screen in use, a different milliammeter scale or calibration curve is required, but as the range of the instrument without the absorbing screen overlaps many hundred degrees with the range for the absorbing screen, the accuracy of the two scales can always be checked by observing a hot body whose temperature lies within this range.

The readings obtained with this instrument are always the same for the same temperature, if the body viewed is surrounded by other objects, such as the walls of a furnace at the same temperature. Also, no correction is required in the case of so-called "black bodies," such as incandescent carbon, when viewed in the open. For iron and steel in the solid state, the corrections required for readings taken in the open are also negligible.

The instrument can be calibrated by sighting it upon bodies whose temperatures are known. either by means of a thermocouple pyrometer, or by the melting or freezing of various substances. The constancy or reliability depends upon the constancy of the lamp; that is, its ability always to shine with the same intensity when receiving the same current. This matter has been investigated exhaustively by the United States Bureau of Standards and by the Nela Park Laboratory of the National Electric Light Association, also in the laboratory of the Leeds & Northrup Co., and it has been found that after a tungsten filament is thoroughly aged—that is, burned for some time at a temperature higher than that to which it will be subjected in service—no sensible variation occurs. The instrument is so designed that one lamp can quickly be replaced by another, and by keeping two lamps, their correctness can be insured by checking one against the other.

The instrument itself is handy and portable, weighing but a few ounces, and can be sighted as easily as an opera glass. The case, containing the battery, rheostat and milliammeter, is designed to be slung about the neck, and weighs about ten pounds.

Benzol and Gasoline Mixture as a Motor Fuel

Experiments recently conducted by a large oil company proved that not only is benzol more valuable than gasoline as a motor fuel when used straight, but its effective value is increased by being mixed with gasoline. These experiments indicate that a mixture of equal parts of gasoline and benzol gives a value over 16 per cent. greater than that of straight gasoline, which shows 32 per cent. increased value for the benzol half. In many quarters alcohol is looked upon as the ultimate fuel, but it cannot be employed except with great difficulties, owing to its high hydrogen content. Commercial alcohol and gasoline are not miscible, but alcohol and benzol are miscible and make a good fuel, and further, after the addition of benzol to alcohol the mixture will carry a high proportion of gasoline. The future may see benzol as the tie between gasoline and alcohol, permitting a piecing-out of the gasoline supply and an introduction of alcohol as a commercial motor fuel.—*From a paper by C. J. Ramsburgh and F. W. Sperr, Jr., Pittsburgh, Penn.*

Rotary Engine Built in 1870

Something about a small rotary engine that was built to drive the original Hendey machine shop. It is of three horsepower capacity, and the steam admission is controlled by a flyball governor

ROTARY engines come and go, and many of them never get past the experimental stage. The one shown in Fig. 2, however, has an interesting history, and for eight months produced power for a machine shop that has outgrown its original size as completely as the little rotary engine has been distanced by the present power plant. Back in 1870 a machinist, Henry J. Hendey, was working for $5 per day, a high wage for those times. He became dissatisfied with working for others, and decided to go into the machine-shop business for himself. He had ideas of his own, and he proceeded to build the engine that was to run his shop.

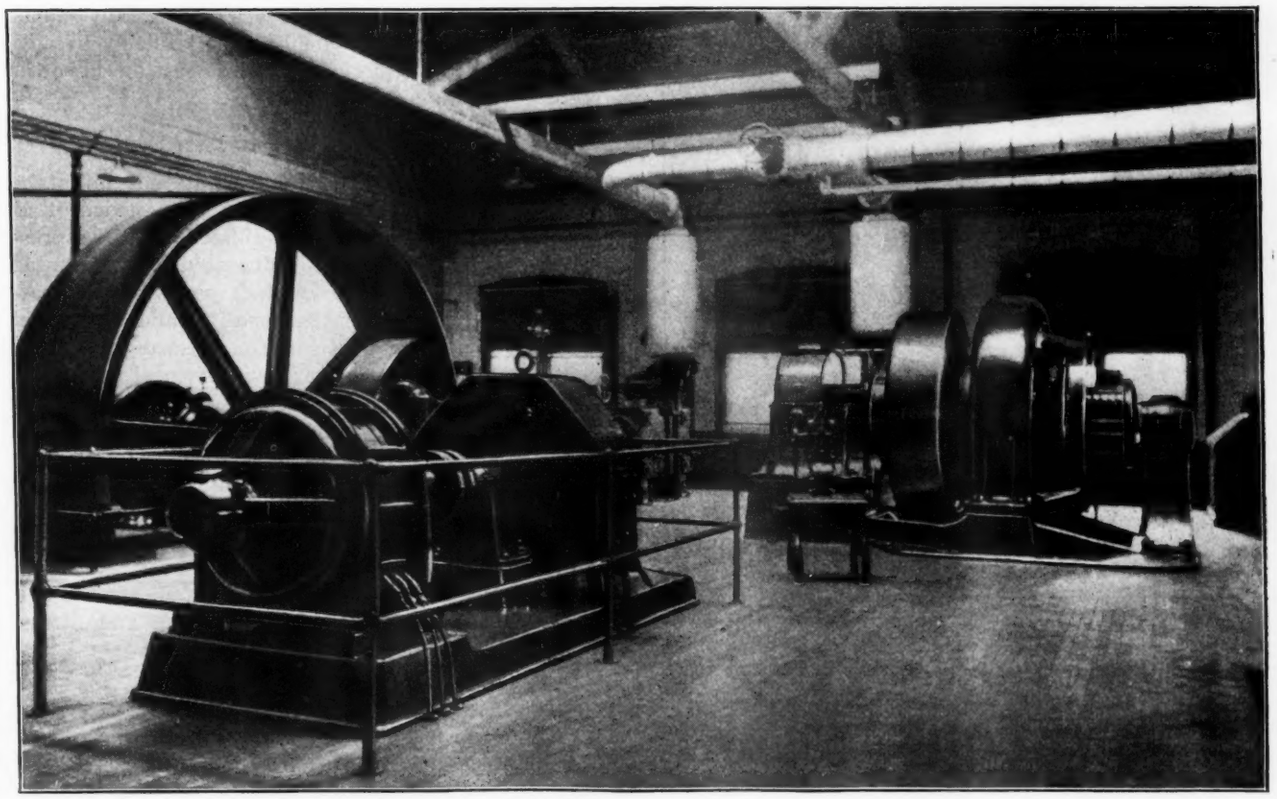


FIG. 1. PRESENT ENGINE-ROOM EQUIPMENT. THE ROTARY ENGINE IS SHOWN ON THE STAND IN FRONT OF THE ENGINE

By working at night after a day's work, he finally completed the machine shown in Fig. 2.

Nobody about the present works has any knowledge of the interior construction of this engine. It consists in the main of a casing in which a rotor revolves. The heads of the casing are removable, and each is fitted with a stuffing-box bearing for the shaft that extends through them at each end. One end of the shaft carries a small pulley that is belted to the governor shaft. The other end of the engine shaft extends through an outboard bearing and carries a driving flywheel.

On top of the rotor chamber is a steam chest in which is a semi-rotary valve that is actuated by the movement of the governor through the link, as shown. The governor is belt-driven, and bevel gears drive the vertical spindle. As the governor balls revolve and rise to a higher plane, a central spindle is forced downward, and the lever and link controlling the steam valve are also moved, thus cutting off the steam supply.

Connecting with the steam chest on one side and extending to the bearing hub on each head is a pipe. It is not known just what these connections are for, but it would appear that they are to supply steam on both sides of the rotor in order to counterbalance the end thrust.

It is not known what kind of a boiler supplied steam to this engine, but it is supposed that it was a small vertical one. The outfit ran the machinery in the first shop that Mr. Hendey built, which was a small one-story building. The first working force was one man and a boy. Today the works employ about one thousand men. Arthur Hendey, a brother of Henry, afterward became associated in the work, and the business was carried on as Hendey Brothers, and later was incorporated as the Hendey Machine Co., Torrington, Conn. Arthur retired on account of ill health and is still living. Henry, the designer of the rotary engine and the founder of the present company, died about ten years ago.

In Fig. 1 is shown the present power plant of the company. It consists of one 400- and one 500-hp. steam

engines, and one 100-hp. generator set. A comparison of the first and the present power plant is shown, the rotary engine standing between the motor generator set and the 400-hp. engine.

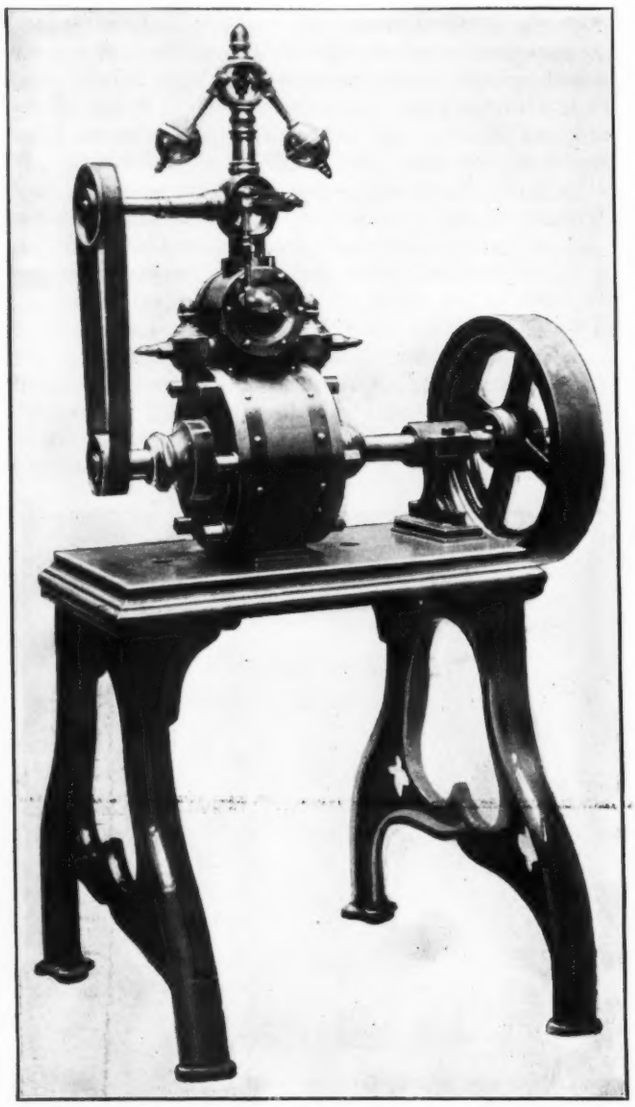


FIG. 2. 3-HP. ROTARY ENGINE BUILT IN 1870

The rotary engine is still in running order and rests on a table, and is kept as a relic of the early history of the company. The workmanship is of a highly finished class and reflects the skill of the builder.

Economy in Lubrication

By A. J. Dixon

Lubrication is an item in the operation of a power plant that calls for critical study of individual requirements, if it is to be done as economically as the possibilities will allow. It is a question that cannot be settled in any particular case by conforming to established rules and formulas. It is measured by no fixed standard of efficiency. The engineer must figure it out to suit the peculiar conditions before him, and his rule of guidance must be good judgment and common sense, based mainly upon his own observation and experience with the work in hand.

The problem of lubrication is essentially a study of the phenomena of friction. While the losses caused by excessive friction can be measured with accuracy, still the means necessary for the purpose are not usually so convenient of arrangement and manipulation as to make feasible a continuous and complete record of the discovery and correction of such losses in any set of bearings. Nevertheless, without sufficient reliable information regarding the frictional resistances to be overcome, the problem of lubrication can be approached only in a haphazard, uncertain way. A variety of lubricants adapted to the different friction-reducing requirements found in the diversified equipment of a power plant cannot be selected intelligently unless a good deal of experimenting is done to find out exactly what is needed in each case, nor without a precise tabulation of the observed results. The fact that a shaft journal, a worm gearing, a clutch coupling or the like runs cool with the application of a certain quantity of a certain kind and quality of lubricant does not necessarily signify the highest percentage of lubricating efficiency. A little experimental investigation might reveal the fact that a much less quantity of another and better adapted lubricant would materially reduce the wear by friction, thus helping the economy by adding to the life of the mechanism while cutting down the current operating expense.

Pressure Should Be Distributed Evenly

In justice to any brand of lubricant that might be submitted for trial, the apparatus upon which it is to be used should first be so adjusted that the pressure between the parts to be lubricated be distributed over the available bearing surface as evenly as possible. Lubricants of identical quality, and applied in exactly the same way to a common class of apparatus working in different situations, will often show a wide discrepancy in the economy obtained, even when to cursory view the operating conditions are likewise exactly the same. Very often it will be found that where a journal gives no bother with a liberal quantity of oil or grease fed to it, it will behave just as satisfactorily with a considerable reduction in the quantity of lubricant applied after an accurate realignment of the mechanism to which it belongs and after some attention has been given to the grooving and fitting of the bearing.

Excessive Oil Wasteful

A case in point was where an engineer thought it necessary to use a special lubricant for the crankpin and mainshaft journal of a motor-driven horizontal ammonia compressor. The lubricant was a high-grade cylinder oil diluted with a small proportion of thin engine oil. By feeding this mixture in a continuous stream from the cups, the bearings ran only moderately warm, and the engineer was disposed to congratulate himself upon the result. In the course of events another engineer took charge of the plant. To this man's sense of values the lavish lubrication previously employed seemed an irregularity, and he set about finding a way to correct it. After he had elevated the outer end of the crankshaft slightly, he found that the crankpin and shaft journal ran practically stone-cold with the ordinary filtered oil fed to them drop by

drop; also, he noticed an appreciable lessening of the load on the driving motor.

Preventable friction in the machinery of factory plants often goes on for months unobserved, insidiously consuming energy that might otherwise return a substantial profit. The extra load thus imposed on the engines may foot up to enormous proportions in the course of a year's run, and still the engineer continues unaware that anything is wrong. He may conclude that because all the bearings run cool, or comparatively so, the situation leaves nothing to be desired in the way of lubrication. As exemplifying the condition may be mentioned a factory building in which a long line of shafting was hung from the ceiling of the first story. While the journals never really ran hot, they showed a tendency to acquire an undue degree of heat at odd times, necessitating extra attention and a more abundant use of oil than usual to keep the heating within safe limits. The engineer in charge finally determined to find the cause. His investigation showed that it was due to a sagging of the second-story floor, imperceptible to ordinary inspection and varying as the weight of material deposited on the floor was increased or diminished. The remedy was simple. It consisted of a row of concrete piers built in the basement up to the first-floor level, from which the second floor was shored up with iron columns. There was no further difficulty with the lubrication of the shaft journals. Incidentally, the indicator showed the engine to be developing nine horsepower less for the same output in the factory.

Defective lubrication sometimes defies every method of cure that conservatism in such matters might suggest, correction being finally effected only by the use of some unique and apparently hazardous mode of treatment. An unusual case was where both crankpins of a cross-compound engine in rolling-mill service persisted in running hot, despite the fact that the pins and brasses were generously proportioned, had ample oilways and showed perfect contact surfaces, the engine being in good alignment in all respects and running smoothly. After worrying along for some months, the engineer, noticing the close-grained character of the metal, finally concluded that the brasses made such intimate contact with the pins as to exclude all chance of a sufficient film of oil forming between the surfaces under the extra pressure of the intermittently applied maximum load. With a light ball-peen hammer he went over the surfaces of the pins and covered them with a multitude of dents so slight as to be hardly perceptible to the eye or touch. When the engine was again started, the difficulty had disappeared. The indentations simply provided so many minute shallow oil wells, each collecting a quantity of the oil supplied and distributing it to the adjoining high spots.

"Simplex" Water Gage-Glass Guard

The device illustrated herewith is a safety guard designed to remove the danger of being scalded by escaping water and steam or injured by glass thrown from broken water gage-glasses.

It is easily and quickly applied to any type, size or make of water gage. It consists of a nonrusting semicylindrical shutter S (Fig. 1), rotating in brass semicircular tracks T and T_1, one mounted at the top and

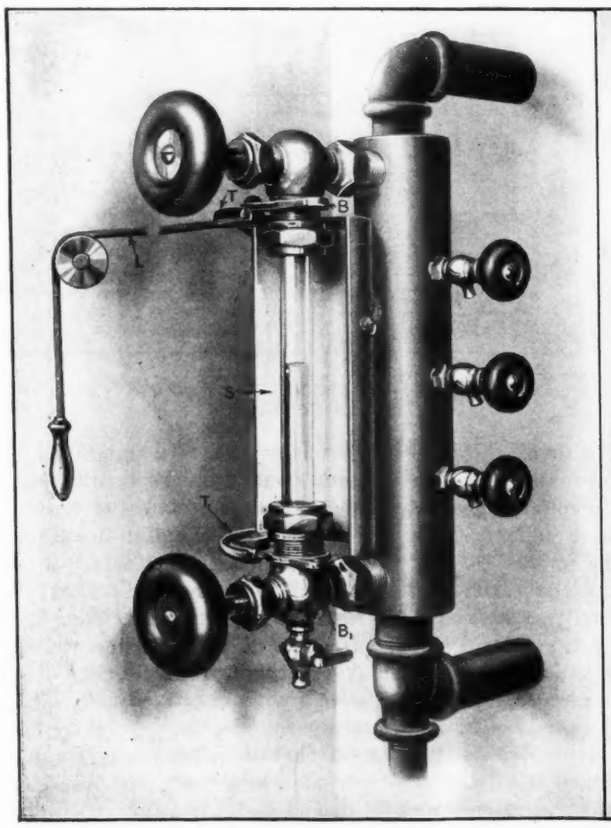


FIG. 1. GUARD IN RUNNING POSITION

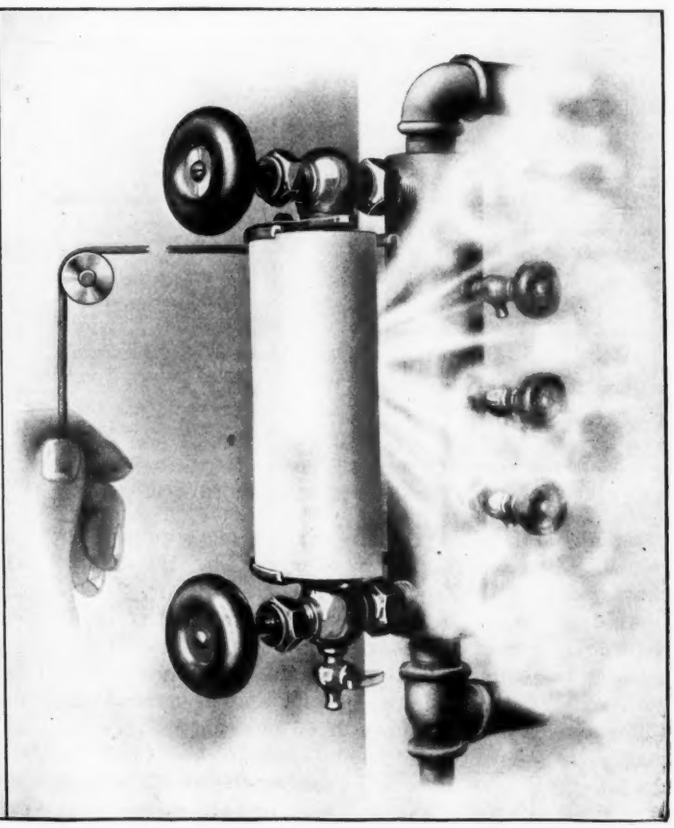


FIG. 2. GUARD SWUNG TO PROTECT THE FIREMAN

one at the bottom of the gage, these tracks being concentric with the gage-glass itself and attached by means of screws to the rod brackets B and B_1, after removing the guard rod (Fig. 1). To this shutter is attached a cord L which passes through an eye on the outer periphery of the upper circular track and from there extends to any point convenient to the fireman.

When a gage-glass breaks, the fireman pulls the cord and the circular shutter moves through half a turn and deflects the escaping water and steam, making it possible to shut off the gage-cocks without any danger of being burned (Fig. 2). When this has been done, another quarter-turn removes the shutter from its tracks and it drops out of the way enough to enable renewing the broken gage-glass. The shutter is then put back into its tracks in the guarding position (Fig. 2), and the valves on the gage-cocks are reopened.

Determining Gas-Passage Areas

By William Carl Stripe

In determining the proper areas of gas passages through steam boilers or of the flues or breechings connecting the boilers and the chimney, it is necessary that the following variable factors be intelligently considered: Boiler horsepower developed; pounds of coal per boiler horsepower-hour; pounds of air theoretically required per pound of coal burned; per cent. of air (theoretically required) actually used; temperature of gases at the point considered, and the velocity of gases at the point considered.

The mathematical processes involved are simple enough, but the number of factors to be considered present a cumbersome and rather tedious calculation.

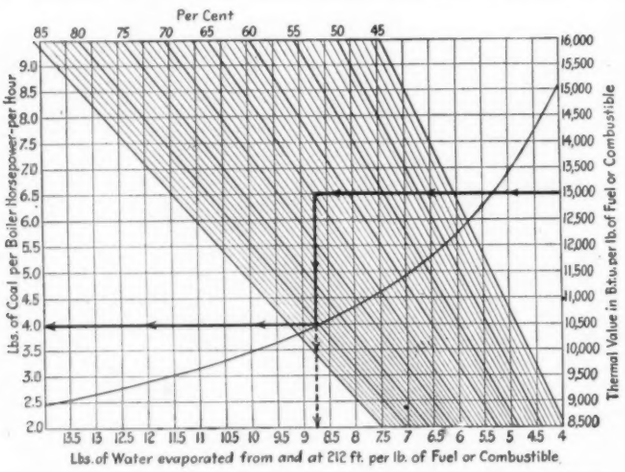

Per Cent
Lbs. of Coal per Boiler Horsepower-per Hour
Thermal Value in B.t.u. per lb. of Fuel or Combustible
Lbs. of Water evaporated from and at 212 ft. per lb. of Fuel or Combustible

FIG. 1. POUNDS OF COAL PER BOILER HORSEPOWER

Equally satisfactory results may be more quickly obtained, with less likelihood of error, by the use of charts such as are shown by Figs. 1 and 2.

An example will be solved to assist in understanding the application of the charts. Let it be assumed that a boiler be operated to develop 1500 boiler horsepower with coal of 13,000 B.t.u. per lb. and at a combined boiler and furnace efficiency of 65 per cent. Referring to Fig. 1, follow the horizontal line marked 13,000 to the left until it intersects the efficiency line marked 65 per cent., then down to the curved line and then to the left margin, where approximately 4 lb. is read as the amount of 13,000-B.t.u. coal required per boiler-horsepower-hour at 65 per cent. combined boiler and furnace efficiency. (Incidentally the number of pounds of water evaporated from and at 212 deg. F. per pound of fuel or combustible is found as 8.75 by projecting the vertical line down to the margin, see the dotted line.)

Now locate 1500 boiler horsepower on the scale A marked "Boiler Horsepower Developed," Fig. 2, as the rating for which the gas passage is to be designed. Project this point vertically to the oblique line marked 4 lb. (which value was obtained from Fig. 1), then horizontally to the oblique line marked 13,000 B.t.u., then down to the line marked 100 per cent. and then to the left to 175 per cent. (assumed per cent. of theoretical air required); next to the temperature (1000 deg. F. as shown) then to the right to velocity in feet per second (35 ft. per sec. is assumed as a reasonable figure)

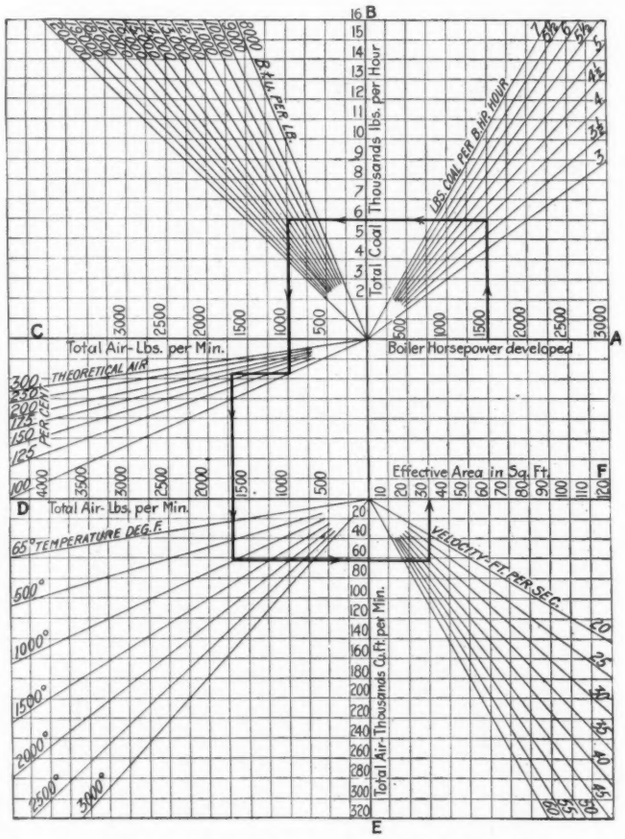


FIG. 2. CHART FOR DETERMINING THE EFFECTIVE AREA OF GAS PASSAGES

and then project vertically to the scale F, where 30 sq.ft. approximately effective area is read as the result.

Probably the only explanation necessary for a complete understanding of the charts is the significance of the values for the thermal value of the fuel, Fig. 2, and the relation of these values to the theoretical air requirements. This is explained by reason of the close relation between thermal value of fuel and the weight of air required, which is practically constant at 7.6 lb. of air per 10,000 B.t.u. over a wide range of fuels. This value was used in preparing the charts.

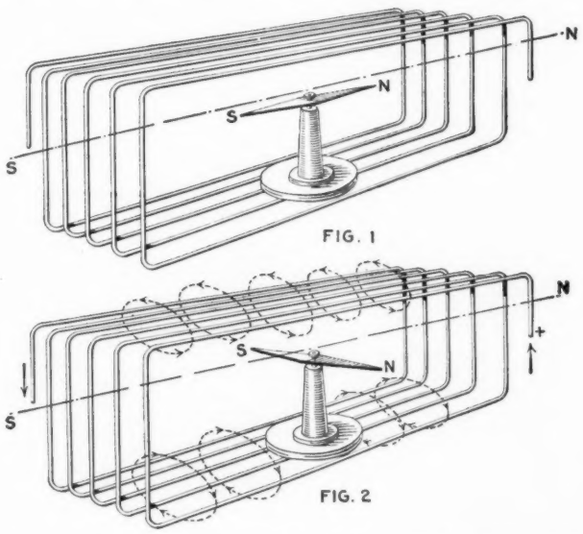
It will be noticed that partial results may be obtained at each of the intermediate scales B, C, D and E. The charts may also be used for determining or checking intermediate factors in the calculation.

The Electrical Study Course—Principles of Electrical Instruments

The principles of operation and construction of one type of voltmeter and ammeter for direct-current circuits are discussed, and the problem given in the previous lesson is worked out.

SO FAR in these lessons on electricity our attention has been called to three effects of an electric current—the magnetic effect, the heating effect and the electrochemical effect. Electrical measuring instruments are constructed on all three of these principles. However, most direct-current instruments, as constructed today, employ only the magnetic effects of the current in conjunction with a permanent magnet; therefore in this discussion only electrical instruments constructed on this principle will be considered, leaving the instruments embodying the other principles for our studies of alternating current where they are mostly employed.

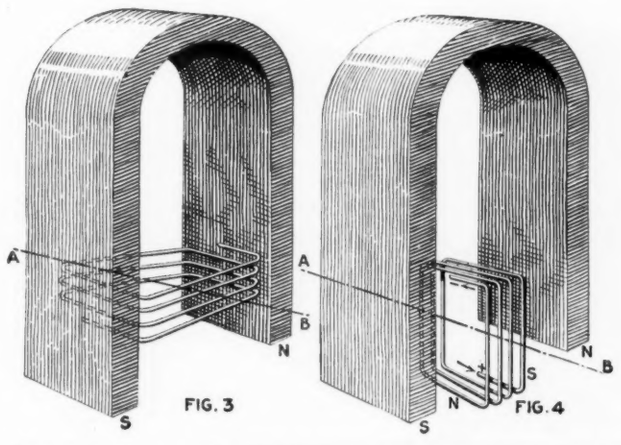
If a coil of wire is placed so that the plane of its turns point north and south, as in Fig. 1, when a compass is placed within the coil, the needle will take a position parallel to this axis, as shown. When an electric current is passed through the coil, it will cause a magnetic field to be set up about the turns of the coil, as explained in the lesson, "Elements of Magnetism—III," in the Feb. 13 issue. With the transverse axis of the coil pointing north and south, as in Fig. 1, the lines of force passing through the coil will be at right angles to the compass needle and will tend to swing the latter from its position parallel to the earth magnetic field. The result of this is shown in Fig. 2, where the needle is parallel to the lines of force, or turned 90 deg. from the position in Fig. 1. The amount that the needle will be turned from its natural position will depend upon the strength of the current and the number of turns in the coil. This scheme is one of the simplest and oldest used for measuring electric current, or voltage, and is called a galvanometer.



FIGS. 1 AND 2. SHOW A MAGNETIC NEEDLE SUSPENDED WITHIN A COIL OF WIRE

The next step is to reverse the order of the elements in Fig. 1 and make the magnet stationary and the coil movable. Such an arrangement is given in Fig. 3, where a horseshoe magnet is shown with a small coil suspended between its poles, the plane of the turns of the coil being parallel to the magnetic field of the magnet. If an electric current is caused to flow through the coil, a magnetic field will also be set up about it at right angles to the line of force from the poles of the magnet, which will tend to cause the coils to revolve about the axis *AB* until the direction of its magnetic field is parallel to that of the magnet, as in Fig. 4. This is the arrangement used in most instruments for measuring a direct current or voltage, and is usually known as *the movable coil between the poles of a permanent magnet type.* It will be seen that the north pole of the coil points to the south pole of the magnet. If the direction of the current is reversed through the coil, it would turn in the opposite direction, consequently instruments built on this principle can be used on circuits only in which the current always flows in one direction.

Fig. 5 shows a complete system of a modern-type instrument embodying the foregoing principle. To concentrate the lines of force of the magnet on the coil, soft-iron polepieces *I* are fastened to the pole faces of the magnet *M*, also a soft-iron core *C* is supported between the polepieces, leaving only sufficient clearance between the core and polepieces for the coil to revolve. The coil *A* is supported on pivot bearings and is prevented from turning by small spiral springs at the top and bottom of the coil; the top spring is shown at *F*. A pointer *P* made from a small aluminum tube is mounted on the coil so that when the coil moves it will be carried across the scale *S*. The scale *S* is supported from the magnet, therefore the entire system may be removed as a whole from the case for adjustment. It



FIGS. 3 AND 4. COIL SUSPENDED BETWEEN THE POLES OF A HORSESHOE MAGNET

will be noticed that the right-hand terminal of the instrument is marked + (positive), and the left-hand terminal — (negative). This is standard practice on all instruments of this type. In this way the instrument may be used to determine the polarity of a circuit.

The movable element of such an instrument must be very light to reduce the friction element to a minimum, so as not to interfere with the accuracy of the indication. Consequently the coil must be wound with very fine wire, which means that it can carry only a very small current. The device shown in Fig. 5 may be used to measure either the voltage or current, depending upon how it is connected in the circuit. If voltage, the coil is connected in series with a high resistance, and if current, in parallel with a low resistance. This will be the subject of the next lesson.

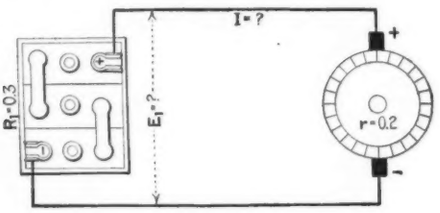


FIG. 6

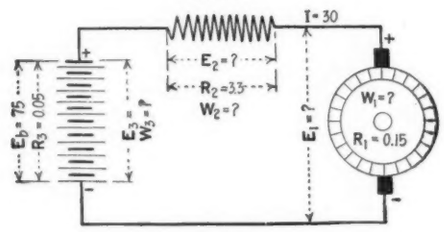


FIG. 7

FIGS. 6 AND 7. BATTERIES CONNECTED TO A DYNAMO

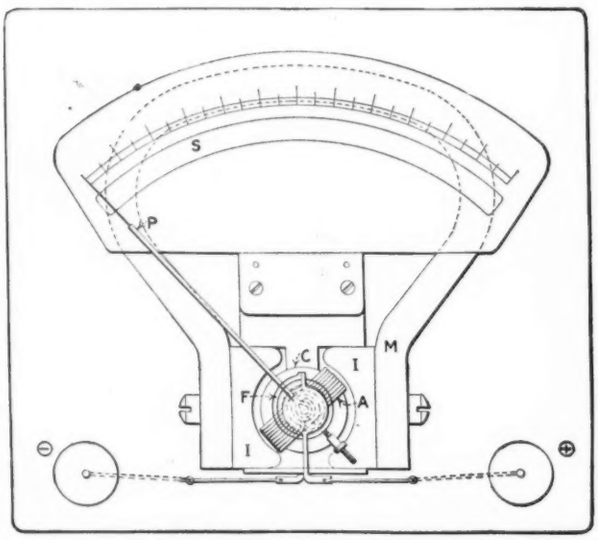


FIG. 5. MOVEMENT FOR A DIRECT-CURRENT VOLTMETER OR AMMETER

The layout of the study problem given in the last lesson is shown in Fig. 6. The battery has a normal open-circuit voltage of 6 volts and an internal resistance $R_1 = 0.3$ ohm, the resistance of the dynamo's armature is $r = 0.2$ ohm, and develops 10 volts. The combined resistance of the battery and armature will be $R = R_1 + r = 0.3 + 0.2 = 0.5$ ohm. The battery is so connected that its pressure will oppose that of the generator, consequently the voltage E effective in causing a current to flow through the circuit will be the difference between that of the dynamo and the battery, or $E = 10 - 6 = 4$ volts. Note that when two electromotive forces oppose each other, only the difference between them is effective, just the same as when two mechanical forces oppose each other. The current flowing in the circuit will be $I = \frac{E}{R} = \frac{4}{0.5} = 8$ amperes. Part of the 4 volts effective in causing the current to flow is used up by the resistance of the battery and part in the dynamo. The voltage required to cause the current to flow through the resistance of the battery equals $R_1I = 0.3 \times 8 = 2.4$ volts, and this value plus the open-circuit voltage of the battery equals the volts, E_1, impressed on its terminals, or $E_1 = 2.4 + 6 = 8.4$. The volts drop through the armature of the dynamo is $E_2 = rI = 0.2 \times 8 = 1.6$ volts.

The study problem is given in Fig. 7. Determine the voltage E that the dynamo must develop to cause 30 amp. to flow in the circuit, the volts drop E_2 across the resistance R_2, volts E_3 impressed on the battery terminals, watts lost (W_1) in the armature, watts (W_2) expended in the resistance R_2, the watts (W_3) supplied to the battery, total watts, kilowatts and electrical horsepower.

Pipe-Line Construction

The photograph reproduced shows the expansion bends, about 136 ft. apart, with anchors midway between, in the steam main being placed under the street at Rochester, N. Y. The pipe is coated and covered, then lowered into the cemented trench and rests on rollers. The job throughout seems to be first-class.

UNDERGROUND PIPE LINE FOR HIGH-PRESSURE STEAM

Editorials

While Important Legislation Waits

PERPETUAL motion cranks and alchemists take heart. Although spurned by science and the engineering world, the benevolent arm of Congress will protect and foster your desires.

A bill has just been introduced in the House by Congressman Church, of California, in the form of a joint resolution, which according to the preamble is "for the purpose of promoting efficiency, for the utilization of the resources and industries of the United States, for lessening the expenses of the war, and restoring the loss caused by the war by providing for the employment of a discovery or invention called the 'Garabed,' claiming to make possible the utilization of free energy."

This far-reaching and mysterious discovery, which, by the way, the inventor will not trust to the searching gaze of the Patent Office, is the product of the brain of Garabed T. K. Giragossian, of Boston. By the terms of the bill the inventor is to demonstrate the practicability of his discovery to a committee of five scientists, *to be selected by him and approved* by the Secretary of the Interior. If this committee reports favorably, the said Garabed T. K. Giragossian shall be recognized by the United States Government and shall be entitled to all rights and benefits thereto for a period of 17 years. If the Government decides to avail itself of the invention, it can do so by reimbursing the inventor.

But one may ask, what is this invention all about? Well, it appears that neither the Congressmen who so valiantly sponsored the bill, nor anyone else except the inventor, is in possession of this pertinent information. We have only the inventor's scholarly address before the Congressional committee, from which to glean some idea of its scope. Quoting from this, "Unlimited energy can be produced without expense or without toil except wear and tear of machinery. . . . The work will bring about absolutely inexpensive and free energy so that we can use that instead of muscle energy. . . . Coal will be more useful for dyes; for alcohol; for tars and for a good many other things. . . . Many or all of you have seen a steamship. When we go there we see ten or fifteen big boilers, sometimes 22 ft. long and 16 ft. in diameter. For that reason we have from 10- to 15-ton machinery, but by my work all of that nuisance will go. . . . My work can be utilized in the airship most successfully. Thousands of horsepower can be put in the airship so that it can circle the globe. . . . My work will supply tractors and automobiles with free energy."

In all some twenty-five pages are taken up by a dissertation on the aims and spirit of the Constitution in protecting inventors; by an attempt to blame the poor old steam engine for the high suicidal rate in Germany; and an indorsement from the enthusiastic Congressmen; all of which is printed at Government expense, not to mention the time of the committee of our learned representatives which must have been consumed in the hearing. Meanwhile important legislation waits.

One might be inclined to see only the comedy in this episode were it not for the seriousness of the present situation.

Ye Gods! Will the time ever come when the sacred halls of Congress shall be graced by the presence of a few men with engineering training?

Oil Shortage in California

THE State of California is producing about one-quarter of the oil used in the world today. In 1914 this production amounted to about one hundred and four million barrels; since then it has been falling off, and during 1916 the consumption exceeded the production by over thirteen million barrels. So serious has the question of oil production become that Governor Stevens of California has appointed a committee to investigate the oil resources of that state, with particular regard to the industrial and military needs of the state and nation in the present war emergency.

Development is usually along the path of least resistance, and conditions that have brought about the present serious oil situation in California would seem to be due largely to following too much the path of least resistance without any regard to the consequences. Oil, when it can be obtained in large quantities, is easily removed from the earth, conveniently transported, occupies far less space than coal for the same heat value and compares favorably in cost with coal, therefore, everything is in favor of using oil as a fuel in the districts adjoining the great oil fields, to the neglect of the use of both coal and water power. The outcome of this has been, as pointed out in the committee's report, that fuel oil operates most of the steam railroads of the Western States, the Panama Canal steamship lines, cement plants, mines and smelters, gas plants, sugar refineries and in general a substantial portion of the manufacturing, industrial and agricultural enterprises of the Western States. Added to this, a large number of naval vessels are oil burning.

This situation might not be so serious if it were not for the fact that according to the committee's report a further substantial increase in the annual petroleum production cannot be expected through the discovery of new fields or large extensions of existing fields. In fact, the Western States today are facing the same prob-

lem in regard to oil that a number of other states are confronted with in regard to natural gas. Natural gas where available has been used for fuel and industrial processes without any heed to when the supply would fail, but recently many of these industries have been forced to use coal on account of the scarcity of natural gas.

Probably the use of natural gas and oil for fuel could have continued for a few more years without serious consequences if normal conditions had existed, but within the last two or three years such abnormal industrial development has taken place as to make the question of relieving the oil situation a serious one. On account of the scarcity of materials necessary for producing oil, and also of labor, it is difficult to increase the production at this critical time. On the other hand, conditions surrounding the production and transportation of coal are such as to make it impossible to change industrial power plants from oil to coal burning. Even if it could be done, it is not to the best interest in conserving our natural resources when hydro-electric power can be obtained.

Hydro-electric energy has been substituted to a considerable extent in industries and for agricultural purposes in the Western States, but its use is hampered at the present time by the difficulty of securing materials. The report states that large oil saving through the substitution of hydro-electric energy cannot be expected during the war, but after the restoration of normal industrial conditions, wherever hydro-electric energy is available, it will play an increasingly important part as a substitute for fuel.

The serious industrial situation that has been brought about by the fuel shortage, including coal, oil and gas, not alone in this country but even more so in Europe, while millions of horsepower that might be developed from waterfalls is going to waste, should emphasize the necessity of developing this inexhaustible source of energy and the conservation of the sources that are not self-perpetuating.

More Authority Needed

IT IS gratifying that people are awakening to the fact that more authority should be, and can safely be, placed in the hands of the Council of National Defense and the Advisory Commission. The work done and the influence exerted by these bodies in their present capacity—largely advisory—have demonstrated the great value of their services to the country in these times of stress and point to their greater usefulness if clothed with authority to decide on and order final action in given cases falling within their prescribed sphere of action. There is work enough as well as "glory enough for all," so there need be no overlapping or usurping of the functions of established Federal agencies.

The formation of a board of national defense with power to act on its own authority has been proposed by Waddill Catchings, chairman of one of the committees of the Chamber of Commerce of the United States at Washington, as a means of solving one of the difficult problems at present confronting the advisory organization. He points out that the machinery of the Government was developed for peace times and that the newly created councils, boards and committees act more or less independently of one another. The Council of National Defense, generally thought to be a means of developing concentrated effort, was created in time of peace and is vested with no power to act, and unless granted this power, it cannot become a central organ of defense in time of war. The wonder is that so much has thus far actually been accomplished rather than otherwise.

Attention has been directed many times in our columns to the splendid work of this and other bodies giving freely of their time and unsparingly of their energy and experience, as no other consideration than a national peril could cause them to do.

A consultation of top-notch physicians on a given case is a fine thing professionally, but the patient is interested in results and they can be attained in only one way. The council should be given the authority to see that its plans are put through.

Another Way To Do Your Bit

THE Department of Labor announces that it has inaugurated a plan for mobilizing adult male volunteers for service in employment of every kind, public and private, which is necessary to the effective conduct of the war. Those willing to engage in such service whether in a voluntary or in a wage-earning capacity, are asked to enroll as members of the United States Public Service Reserve. Detailed information as to the qualifications of each member will be secured, studied and recorded. Arrangements have been made to get prompt information of opportunities for service. Available members will be put in touch with Governmental departments and other employers who need men for work of value to the nation.

The magnitude of the war has not yet reached adequate realization in the minds of Americans generally. It is only as time goes on, with the changes that it will bring in the industries and in personnel everywhere in the business and industrial world, when the huge armies being drafted are mobilized, when the casualty lists are given in the press and the streets show wounded convalescents, that the average man will appreciate how great is the work which the people of this country have entered upon.

The Public Service Reserve offers excellent opportunity for many men engaged in occupations that may, without appreciable loss to anybody, be laid aside until after the war, to direct their services in those channels where the greatest good may come of them in our struggle to uphold and maintain the principles laid down by our forefathers in building this first and greatest of republics. Apply to the United States Reserve, Department of Labor, Washington, D. C.

Correspondence

Energy Released by Boiler Explosion

An article in the issue of June 12, page 788, it seems to me, presents direct evidence relating to the recent discussion regarding the energy released in a boiler explosion (pages 474, Apr. 10; 605, May 1; and 669, May 15).

It is a description of some of the results of an explosion of a cast-iron economizer. The initial pressure before rupture was moderate but the explosion must have been a very sudden process. In the previous discussion much attention was given to the question whether the work done in displacing the atmosphere should be excluded from the destructive effect. In this case the displacement of the atmosphere was responsible for most of the destruction of property, for surely the flying pieces of iron did not carry off bodily 5000 square feet of roof and injure a large additional area as well as knock out a section of the side wall. This destruction was wrought by the air set in motion by the explosion.

Air Inertia and Pressure to be Overcome

But, it may be argued, the atmospheric pressure on top of the roof and outside the walls resisted the destructive effect and should therefore be subtracted. It is true, of course, that the atmosphere resists the motion of any body, but the amount of this resistance does not depend solely upon the pressure of the atmosphere and the volume displaced. The velocity with which the body moves or attempts to move is an extremely important factor. A simple illustration which, no doubt, many of your readers have tried, will serve to make this point clear. Balance a light board across the top and over the edge of a bench so that it just escapes falling off. Then spread a newspaper (several sheets thick) over the end of the board on the bench, and strike the overhanging end of the board a very quick blow with the fist or a hammer. It will be almost impossible to tip the board, and if the hammer is heavy and the board light, the blow may be sufficient to break the board.

In this case the energy of the moving hammer tends to destroy the board solely because the atmosphere resists the rapid motion of the other end of the board. The amount of this resistance cannot be computed. It does not depend on the pressure of the atmosphere solely or even in any important manner. It depends chiefly upon the resistance of the atmosphere to being suddenly displaced—the inertia of the air. So in the boiler explosion it is undoubtedly true that the atmosphere, owing to its inertia, tends to cushion the sudden expansion and thus reduces somewhat the destructive effect at first. However, this phase of the process is quickly passed, the air is set moving violently and once in motion, tends to keep going, so that when it meets with some resisting object, such as a roof or wall, it piles up a high pressure behind such obstruction, usually sufficient to overcome the strength of the structure. This action is exactly analogous to the occurrence of water-hammer when a moving column of water meets with a valve or elbow. We might term this phenomenon "air-hammer." It is responsible for a large part of the destruction resulting from explosions of all kinds.

In this case the work done in moving the atmosphere cannot be measured as a product of its pressure by any change in volume since we are not concerned with a slow pushing back of the surrounding medium, but with a sudden movement which necessarily does much work in developing a high velocity of the air. Since we do not know this velocity or the weight of air involved, it is impossible to compute the amount of energy required to overcome this resistance. Furthermore, the overcoming of this resistance results in setting in motion the resisting air, which in turn meets obstructions and produces destructive effects.

For these reasons it seems to me impossible to make any deductions from the energy liberated on account of atmospheric resistance. I stand with those who hold that the destructive effect is most nearly approximated by the larger figure cited in the former discussion.

C. H. Berry,
Assistant Professor of Power Engineering,
Ithaca, N. Y. Sibley College, Cornell University.

Liquid Accumulated in Brine Cooler

With warm weather the operators of a combined cold-storage and packing-house plant began to experience trouble in keeping down the temperatures. The cold-storage building had been put in service during the preceding winter, and in connection with this a 150-ton exhaust absorption plant had been installed to care for the cold storage and take over part of the packing-house load, as the latter plant was badly overloaded.

The brine system was used throughout. The original packing-house system consisted of three compressors working on two large brine tanks and two ice tanks that had been installed to supply the ice needed around the plant and for the refrigerator cars. The brine for the ice tanks was pumped directly from the two large tanks, and after going through the ice tanks it circulated through some of the coolers and back to the brine tanks again. In passing through the ice tanks the temperature of the brine was lowered 3 to 5 deg. below that at which it left the brine tanks. For this reason the brine from the ice tanks was used on the lowest-temperature coolers. A 50-ton machine was run on the ice tanks during the warm season, and when the demand was light the machine was cut off and the required ice made by the brine circulated directly from the brine tanks.

When the new absorption plant was installed for the cold storage, sufficient capacity was provided to take

over the ice tanks. A 50-ton unit connected to a brine cooler was provided to take care of the low-temperature cold-storage brine, which was carried at 15 deg. below zero. The remaining 100-ton unit was operated for the ice tanks and for another brine cooler for high-temperature brine (15 deg. F. above zero) for cold storage. This left the original packing-house plant working on the two large brine tanks alone. The 100-ton absorption machine was also working partly on the same system through the ice tanks although the ammonia systems were kept independent. The load on the packing-house plant had been further reduced by putting in cold storage some of the products that had been kept in the packing-house coolers. So there was every reason to expect that no trouble would be experienced during the coming summer in maintaining the required temperatures and making all the ice needed.

Plant Balks When Most Needed

With the first spell of hot weather came a heavy demand on the plant. About this time the 100-ton absorption machine began to get balky; it would work very nicely on either the ice tanks or brine cooler alone, but would not operate well on both together. From about 10 or 11 p.m. until about 9 or 10 the next morning it went along nicely. Toward the latter part of the forenoon the temperature of the cold-storage brine would begin to go up, and soon the frost would begin to come off the expansion valves on the ice tanks. The temperature of the cold-storage brine would keep going up at an increasing rate and the brine from the ice tanks, instead of being a few degrees cooler when leaving the tanks than when it entered, as it would have been under normal conditions, would be the same or a few degrees warmer, indicating that the machine was doing little if any, work. This would continue until about midnight, when it would apparently work very well.

Nobody was able to determine the cause of this trouble, nor could anyone offer a logical solution. The only remaining thing to do was to run the machine on the brine cooler alone for a while and run the brine down to a low temperature and then run on the ice tanks until the storage-brine temperature got too high. Things ran along in this manner for a couple of weeks until one of the engineers quit and a new man came.

New Engineer Finds Cause of Trouble

The new engineer was young and of the observing, analytical mind possessed by real engineers. After being pestered by questions concerning the machine, the chief assigned him to locate the trouble. In about two hours the young man was back with a solution. He took charge of the machine at about the time in the forenoon when it began to get balky. The first thing he noticed was that the frost on the uncovered parts of the suction line from the ice tanks was thawing off while the line from the brine cooler had an unusually heavy frost. From the point where the two lines connected to the absorber, the suction line was heavily frosted, and as the suction line from the ice tanks was losing the frost, the brine cooler evidently was getting all the ammonia it could handle. If the brine cooler was getting all the liquid it could handle and was still unable to hold the brine temperature, there was only one remedy and that was to lower the suction pressure and with it the ammonia temperature, thus increasing the temperature difference between the brine and ammonia and of course the rate of evaporation. The suction-pressure gage showed 30 lb., or 17 deg. F. The temperature of the brine from the cooler was 19 deg. by this time. The difference between the brine and ammonia temperatures was only 2 deg., and this was insufficient for the work the cooler had to do.

The solution of the trouble was now quite simple. The temperature difference between the ammonia and brine in the cooler was so small that there was practically no evaporation, and the liquid accumulated in the cooler until it was entirely full and there was little or nothing left for the ice tanks. No work was done on either system. A little questioning brought out the fact that the suction pressure dropped to about 20 lb. during the latter part of the night and always took a jump in the morning. The load on the cold storage was practically uniform, so the trouble evidently came from the ice tanks.

Here is where the trouble started. The ice-pulling gang, who also iced the cars and did some other odd jobs around the place, would begin at 7 a.m. and in a couple of hours would pull all the ice frozen during the night. In addition, the brine of the packing-house system, which as mentioned, was part circulated through the ice tanks, went up 3 to 5 deg. every day and was brought down again through the night. After lunch the ice gang pulled all the available ice. The result was that the ice-tank brine went up from 10 to 14 deg. F. every day and the suction pressure went in like proportion, practically putting the brine cooler out of operation and robbing the ice tanks of their liquid ammonia.

The remedy suggested by the new engineer was quite simple. Two men, one for days and one for nights, were put to work at pulling ice continuously and at a uniform rate. After this no trouble was experienced with the machine and nearly 50 per cent. more ice was made. Whenever the amount pulled by these men was insufficient, the gang assisted early in the morning and just before going home at night. E. W. Miller.

Minneapolis, Minn.

The Most Economical Vacuum

Referring to the editorial comment at the end of my letter on higher steam pressures in your issue of July 10, to the effect that the authorities had contended that, "except under unusually favorable conditions, it costs more to maintain over 29 in. vacuum than such low pressures are worth," the very point I was trying to make in this letter was that we are liable to error if we assume any condition as the most economical and therefore fixed. Only a few years ago we were accustomed to other standards, such as 100 deg. superheat and 28 in. vacuum. I recollect a paper before one of the engineering societies which proved indisputably, so it seemed, that to go beyond 28 in. vacuum was more expensive than it was worth.

To the casual reader it would seem as though our standards had advanced one inch. In fact we have tacitly considered this as so. As a matter of fact the older 28-in. standards was for 70-deg. water and the new 29-in standard is for water from 50 to 60 deg., depending on the purchaser.

There is still a margin for improvement in the vacuum in any case, and therefore we are not warranted in saying that hereafter we can concentrate on the pressure end of the heat range as the only possible means for steam-plant improvement.

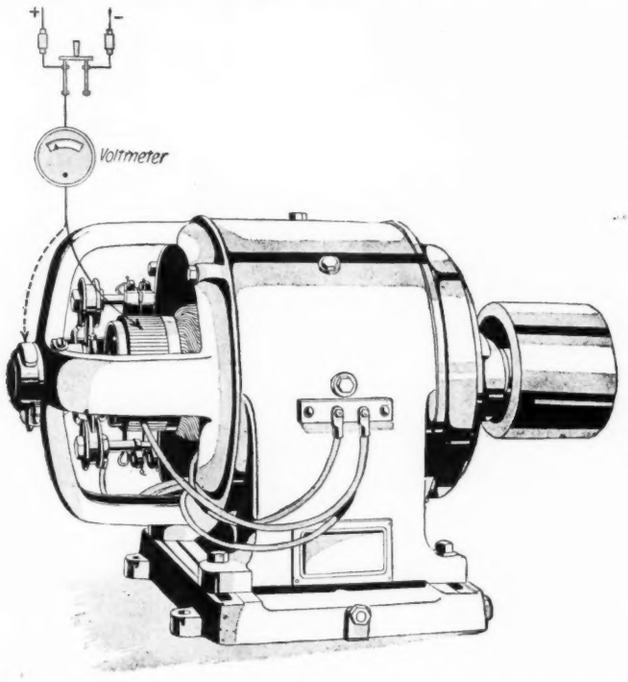
Power, as the leading exponent of efficient generation of energy from fuel, ought to make it its business, in these days of increasing fuel costs, to constantly scrutinize each catch phrase, standard, rule or custom with which we cloak our ignorance and laziness.

In many ways the worst equipment an engineer can have is a notebook or handbook containing standards and rules. Let *Power* be the first to condemn them as they become in the least bit deceptive or abortive.

New York City. PAUL A. BANCEL.

The Motor Was Charged

It should be understood that grounds may exist on both sides of a circuit and be of such high resistance as not to interfere with the operation of the circuit and yet be of sufficiently low resistance to establish the conditions necessary to shock a person standing on the ground and touching either side of the circuit. Furthermore, a circuit that is perfectly free of grounds itself may become dangerous as the result of one of its



TESTING MOTOR WITH VOLTMETER WHEN ONE SIDE OF LINE AND FRAME OF MOTOR IS GROUNDED

conductors becoming crossed with a conductor of another circuit that is grounded.

An operator complained that a new 220-volt motor that had just been installed was so badly grounded that the attendant was unable to give it proper attention, because whenever he touched the motor frame and any part of the copper circuit at the same time, he would get a severe shock. It was natural to attribute all trouble to the insulation, because the motor was new and there was no accumulation of copper or carbon dust on the brush-holders.

As the first step in investigating the conditions, the motor was entirely isolated from the supply circuit and its insulation was tested by means of a 300-volt voltmeter and the 230-volt supply circuit, as indicated in the figure by the full-line connection to the instrument. The insulation proved to be perfect as far as the value of voltage could be depended on to indicate a defect; but it was observed that a 230-volt deflection obtained when the testing line from the voltmeter, as indicated by the dotted line in the figure, was touched to the motor frame, which was grounded to the metal frame of the building. This deflection of full-line voltage showed that one of the conductors of the supply circuit from which the test voltage was derived was dead grounded. The two line conductors were followed back to the source, and one of them was found to be in contact with a third wire that belonged to another circuit. Investigation of the third wire disclosed that it belonged to the circuit of the transformer that supplied the alternating-current motor of a motor-generator set. On clearing the cross between the alternating- and the direct-current wires, it was no longer possible to get a shock by touching the motor frame and either of the brush-holders. E. C. PARHAM.

Brooklyn, N. Y.

Cure for Rattling Governor

I read with interest the article by J. Lewis on page 778 in the issue of June 5 regarding a cure for a rattling governor, but I wonder how many engineers agree with the principle of this method. I do not believe it is good policy to make changes which throw the governor out of adjustment for the sake of putting a stop to the rattle. Why not bush the links and make new pins and adjust the governor to its original sensitiveness?

If the pins and links wear excessively, it is better to try a different method of lubrication or, possibly, different metal. The danger does not lie in this case where no bad effect has resulted, but in the fact that it may be tried by others who do not have the necessary sense and good judgment to know when the cure will work and when it will not, and there are many men in this class in the power-plant field.

Recent observation has convinced me more than ever before that there should be some kind of inspection and license law in every state, and the more uniform the laws are the better.

A superintendent of schools of a large city sent out a great number of letters to business men of the city asking what, in their opinion, should be the general trend of the instruction given to high-school pupils. The answer from a great majority was, "Train them to think." To this the writer would add "Teach them accuracy," for the power plant needs men who are trained to "think accurately." It is my endeavor to train the operating crew to think things out for themselves. As an illustration, in a certain power plant which consisted, in part, of a 750-kw. turbine and surface condenser, the condensate was returned to the feed-water heater in the boiler room. The boilers were fed normally by a three-stage centrifugal pump with a reciprocating pump as a stand-by, each pump being served by a separate heater. Upon entering the en-

gine room about 8 a.m. one day, the chief found the turbine had been running noncondensing since 10:30 the previous evening, caused by the hotwell pump refusing to work, which allowed the condenser to fill up.

The chief took the operator to the boiler room and told him to examine the valves controlling the discharge from the hotwell pump to the heaters—both were found closed. The centrifugal boiler-feed pump had given trouble the previous evening, and in changing pumps the fireman had closed the valve to one heater without opening the one to the other, thereby gradually flooding the condenser, and three different watch engineers and three firemen had been on duty during the period of the trouble and none of them had found the cause.

These men had for years been under the charge of a man who had no ability to develop their thinking power. It is no more than just, however, to state that this particular equipment had been in operation only a few months and only one of the operators had had previous experience with condensers. C. B. HUDSON.

Ithaca, N. Y.

Construction of Turbine Pumps

In reading a reprint of Mr. Chorlton's paper entitled "Notes on the Construction of Turbine Pumps," read before the Institute of Mechanical Engineers in England, which reprint appears in the June 1 issue of the *Engineer*, I was particularly interested in the following section concerning bedplates:

THE BED AND OTHER DETAILS—In the past less importance has been placed on the effect of the bedplate than is now the case, with the result that frequently very shallow depths were used. These early beds were much too weak to resist warping strains due either to the unevenness of the foundation surface, the "pull" of holding-down bolts, or to the reaction of the torque from the motor end. It was a common practice to design bedplates in the form of two separate horns or branches, and in this case deeper sections were generally employed. This form of design, while undoubtedly stronger against bending, depends too much upon the skill of the plant erector and the solidity of the foundation always to give good results. It must be obvious that if fine internal clearances, such as have been dealt with, are an advantage, then the common base for the lot—the bedplate—must be of a nature to insure the clearance remaining concentric and also to maintain true alignment with the operating motor. For these reasons deeper sections than are usual are an advantage.

Mr. Chorlton's remarks with regard to bedplates are most true, and he might also well have mentioned misalignment due to unusual pipe strains.

As builders of turbine units we are keenly aware of the fact that perhaps 90 per cent. of the troubles on turbine units occur immediately after installation and are almost invariably due to ignorance of the necessity of the two or more machines of the unit being in the same perfect alignment that they were when erected and tested at the manufacturer's works. In other words, customers are painfully ignorant of the fact that baseplates, no matter how heavy, are easily strained sufficiently to cause misalignment that is serious in high-speed units; and also that the piping to turbine units is usually relatively large compared with the size of the unit and if not properly designed and erected can often produce strains which will cause appreciable misalignment, particularly if the pipe connections are on the upper part of the machine.

The burden of educating customers to avoid these troubles has up to the present always been on the manufacturer in addition to its being a source of great expense, as customers usually insist that they are blameless when it comes to paying the bill for realigning of the units and the damage done. I am sure that all turbine manufacturers would welcome any assistance the technical journals can give in educating the public.

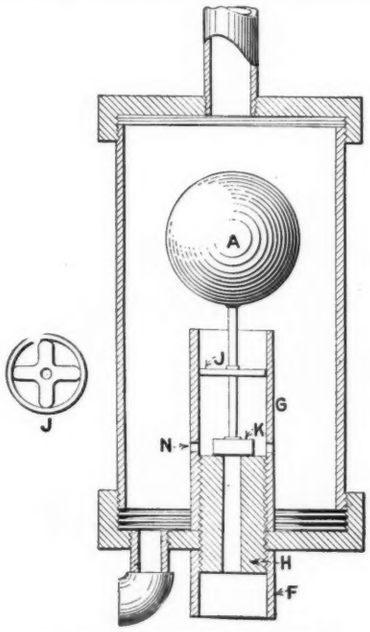
N. L. SNOW, Vice President,
The Terry Steam Turbine Co.

Hartford, Conn.

A Cheaply Made Grease Trap

In many power plants the exhaust steam is used after passing through separators, and the drips are piped directly to the sewer in many cases. This should never be done, for the reason that the separator drips may become closed by thick oil and the separators cannot operate while the drips are so closed. A grease trap placed between the separator and the sewer is a good thing if located where it can be watched.

The illustration shows a trap that will give satisfactory service and is easily made. A piece of solid brass about 2 in. long and the same outside diameter as a 1-



TRAP FOR LOW PRESSURE

in. pipe is drilled $\frac{3}{8}$ in. through the center and threaded 1 in. The pipe-size outside upper end is made flat and true for a valve seat, and it is screwed into the bottom cap as shown at *H*. *G* is a $1\frac{1}{4}$-in. brass pipe threaded on the inside and screwed to *H*. Several $\frac{1}{4}$-in. holes are drilled in this pipe, as shown at *N*. At the bottom of the float rod there is a flat brass disk to serve as a valve. *J* acts as a guide and can be made from a brass washer and soldered to the rod.

The outlet *I* should discharge into a funnel, thence to the sewer. Should the separator pipe drip become blocked or the trap quit working, it will soon be noted. A grease trap is of course a low-pressure steam trap. An indicator glass can be placed on the pipe if desired, to observe the water and oil level in the trap.

Portsmouth, Ont., Canada. JAMES E. NOBLE.

Inquiries of General Interest

Pumping Water Received Under Pressure—Will a double-acting steam pump that can discharge against a head of 20 ft. be capable of raising water to a tank 100 ft. high if the pump is supplied with water under a head of 85 ft.?

W. F. C.

The force required to overcome the discharge pressure depends on the difference of pressure on each side of the water piston. Hence, if the pump is capable of discharging against a head of 20 ft. when the suction water is delivered at the pressure of the atmosphere, then with the suction delivered under a head of 85 ft., the discharge could be against a head of 105 ft., or, without allowance for pipe friction, 5 ft. higher than the tank.

Increasing Capacity of Lineshaft—We have a 1 15/16-in. lineshaft 80 ft. long that is about uniformly loaded to full capacity, with the receiving pulley at one end of the line. How much would the capacity of the lineshaft be increased by having the receiving pulley in the center of length of the lineshaft?

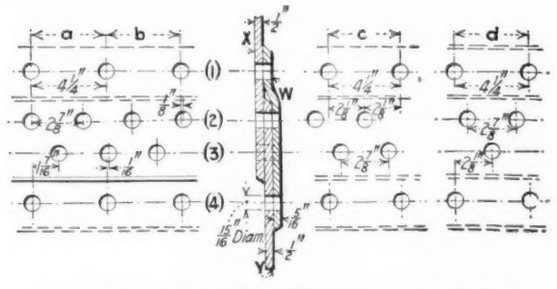
R. B. A.

For a uniformly distributed load, the capacity would be doubled, as by placing the receiving pulley in the center of length, full capacity of the shaft could be transmitted on both sides of the receiving pulley instead of only from one end. In making such a change, however, it should be borne in mind that the receiving shaft, or length of shaft which is to receive twice the present power, should be at least 2 7/16 in. diameter.

Efficiency of Double-Riveted Welt Joint—What would be the efficiency of a double-riveted welt joint, made of ½-in. steel plates and 5/16-in. welt plate, both of 55,000 lb. tensile strength and 95,000 lb. crushing strength per sq.in.; driven rivets 15/16 in. diameter; pitch of outside rows of rivets 4¼ in.; pitch of two inside rows 2⅞ in., staggered; the rivets of the inside rows passing through the lap of the ½-in. plates and the 5/16 welt plate; shearing strength of rivets in single shear 44,000 lb. and in double shear 88,000 lb. per sq.in.?

R. L. H.

Having main plates *X* ½ in. thick and welt plates *W* 5/16 or 0.3125 in. thick, as shown in the sketch, of 55,000 lb. tensile



IRREGULAR DOUBLE-RIVETED WELT JOINT

strength per square inch of section, pitch of outer rows of rivets = 4¼ in. driven rivets to fill rivet holes 15/16 = 0.9375 in. diameter, giving cross-sectional area of rivets = 0.9375 × 0.9375 × 0.7854 = 0.69029 sq.in., shearing strength of rivets = 44,000 lb. per sq.in. of cross-section, or 0.69029 × 44,000 = 30,373 lb. per rivet in single shear; and assuming a crushing strength of plates and rivets of 95,000 lb. per sq.in. of projected area, giving a crushing strength of main plates in front of a rivet = 0.9375 × 0.5 × 95,000 = 44,531 lb., or greater than the strength of a rivet in single shear; and crushing strength of the welt plate in front of a rivet = 0.9375 × 0.3125 × 95,000 = 27,832 lb., or below the strength of a rivet in single shear and also less than the strength of the welt plate between rivet holes in the outer rows (1) or (4): then for each pitch of the outer row,

(A) The strength of solid plate = 4.25 × 0.5 × 55,000 = 116,875 lb.

(B) Strength of main plate between rivet holes in outer row (1) or (4) = (4.25 — 0.9375) × 0.5 × 55,000 = 91,094.

Also the following should be taken into consideration:

(C) Strength of main plate *X* along row (2), plus crushing strength of welt plate *W* in front of 1 rivet in row (1).

(D) Strength of main plate *X* along row (3) plus shearing strength of rivets in row (2) in single shear, plus crushing strength of welt plate *W* in front of 1 rivet in row (1).

(E) Strength of main plate *Y* along row (3), plus crushing strength of welt plate *W* in front of 1 rivet in row (4).

(F) Crushing strength of welt plate *W* in front of 1 rivet in row (1), plus the strength in single shear of rivets in rows (2) and (3) sheared by main plate *X*.

For any particular pitch space such as *a*, *b*, *c* or *d* the least values obtained for (C), (D), (E) and (F) would depend on the cross-sectional area of rivets occurring in rows (2) and (3).

For one rivet occurring in row (2), as shown in pitch space *c*,

(C) = [(4.25 — 0.9375) × 0.5 × 55,000] + 27,832 = 118,926 lb.

For two rivets occurring in row (3) and one rivet in row (2), as in pitch space *c*,

(D) = [4.25 — (2 × 0.9375)] × 0.5 × 55,000 + 30,373 + 27,832 = 123,517 lb.

For two rivets occurring in row (3) as in pitch space *d*,

(E) = [4.25 — (2 × 0.9375)] × 0.5 × 55,000 + 27,832 = 93,144 lb.

For three rivets occurring in rows (2) and (3), taken together, as in pitch spaces *c* and *d*,

(F) = 27,832 + (3 × 30,373) = 118,951 lb.

As the least strength is obtained from consideration (B), namely, 91,094 lb., the efficiency of the joint would be

$$\frac{(B)}{(A)} = \frac{91{,}094}{116{,}875} \text{ or } 77.9 \text{ per cent.}$$

Connecting Pitot Tube to Gas Main—How should pitot-tube connections be made to a gas main for measuring the velocity of the gas?

B. W. E.

To test average velocity, the open end of the bent tube for receiving the velocity pressure should point "upstream," or against the direction of flow, with the center of the opening away from the inside of the gas main a distance of 0.15 of the inside diameter of the main and should be connected strictly gas-tight to the high-pressure leg of the U-tube pressure gage. The other leg of the U-tube should be connected to the side of the gas main about 90 deg. around from the pitot tube with its open end connected to a hole in the side of the pipe that is free from burrs and flush with the interior surface of the gas main. It is important that the latter connection should be made strictly gas-tight both with the wall of the main and in its connection with the U-tube, and, for obtaining correct readings, the connections with the gas main should be made in a straight section of the main and situated not closer than about eight diameters of the main from any of its branch connections or elbows.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Relation of Boiler Efficiency to Capacity*

By VICTOR B. PHILLIPS
Engineer with Cleveland Railway Co.

The author shows that 90 per cent. of the cost of producing steam is for fuel and fixed charges including labor. These two charges are of almost equal importance, and their reduction depends respectively on the attainment of efficiency and capacity. The writer aims to establish a procedure for determining the relation of maximum efficiency at various loads to those variable operations which the fireman may observe and over which he must exercise control.

THERE are two ways in which the cost of producing steam may be reduced. They are efficient operation and the attainment of high capacity. Table I gives typical figures for the various elements of cost entering into the production of steam according to the accounts of the Cleveland Railway Co. for 1914. The numbers shown in parenthesis refer to the accounting system prescribed by the Interstate Commerce Commission. This table shows the predominating importance of fuel and fixed charges, and hence the importance of both efficiency and capacity and their interrelation. Table II is a condensed summary of the data obtained in tests by the writer in the boiler room of the Cleveland Railway Company.

TABLE I. COST FACTORS IN STEAM PRODUCTION

Cleveland Railway Company

		Per Cent. of Total Cost	
1 (53)	Fuel	50.1	50.1
2 (54)	Water	3.4	....
3 (55 & 56)	Oil and miscellaneous supplies	0.4	....
4 (46 & 47-A & B)	Maintenance	6.4	....
5 (52-A)	Employees	9.6	9.6
6 (50)	Depreciation, 4½ per cent. on investment	11.3	11.3
	To these must be added interest, taxes and insurance, 7½ per cent. on investment	18.8	18.8
	Total cost of producing steam	100.0	
	Fuel and fixed charges	.....	89.8

TABLE II. SUMMARY OF TEST DATA

Cleveland Railway Company

Test No.	1	2	3	4	5	6	7	8	9
1 Fuel bed thickness	Thin			Medium			Thick		
2 Horsepower output of boiler (steam pres. 150 lb. gage)	452	661	895	500	736	923	504	718	902
3 Dry coal per hour, lb	1695	2450	3700	1960	3100	4000	2690	3600	4320
4 Coal analysis: a B.t.u	12631	12718	12744	12795	12888	12944	12802	12802	12672
b Sulphur, per cent	4.00	4.00	4.00	4.00	4.00	4.00	4.16	4.16	3.93
c Ash, per cent.	13.2	12.4	12.6	12.4	11.8	11.6	12.5	12.5	13.2
5 Air pressure under tuyeres (in. water)	0.46	1.33	2.63	0.55	1.68	2.79	1.03	2.41	3.27
6 Draft in combustion chamber (in. water)	0.22	0.25	0.25	0.25	0.27	0.41	0.15	0.15	0.45
7 Pounds air per hour by meter	20100	30900	42600	15700	30200	46500	20900	37200	43500
8 Average of air by meter and analysis, lb. per hr.	25200	32000	38500	17850	30300	40250	21900	34250	42250
9 Temperature of air, deg. F	66	66	68	66	69	70	79	80	72
10 Temperature in last pass	532	644	734	500	659	771	509	596	728
11 Sensible heat to stack, per cent.	14.5	17.0	14.6	8.4	12.1	14.7	7.6	10.4	13.7
12 Combustile in ash, per cent loss	5.1	4.0	7.6	4.6	10.0	7.0	17.3	17.3	20.0
13 CO loss	0.4	0.8	10.9	6.6	11.2	13.9	14.8	11.4	.....
14 Latent heat of steam in flue gas	3.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.7
15 Over-all efficiency, per cent	70.7	71.2	63.5	66.9	61.7	59.7	49.0	52.1	54.8
16 Furnace efficiency, per cent	85.2	88.2	78.0	75.3	73.8	74.4	56.5	62.5	68.5
17 Output of furnace, boiler hp.	544	820	1100	563	880	1150	583	862	1127

The Test Conditions

The equipment consisted of a Taylor six-retort stoker with extension grate under a Babcock & Wilcox boiler of 5100 sq.ft. of heating surface. The test lasted eight hours and was preceded by a preliminary run under test conditions, the boiler and furnace setting under heat for several days before the test. Readings were taken every 15 minutes. Air delivered to the furnace was measured by pitot tubes placed in the air ducts and preceded by baffles to create parallel flow. Temperatures were obtained by thermo-electric pyrometers. The fuel bed was kept uniform and constant in thickness by close and frequent observation by three men. All ash was spread out on a large concrete floor, crushed to about 1½ in. and dried before weighing. The sample for analysis was taken by dividing the ash, when evenly spread out, into a large number of squares and then moving away alternate squares until a comparatively small sample for grinding was obtained. The samples were analyzed for moisture, combustible, and in some cases for sulphur or volatile constituents.

The efficiency—that is, the over-all efficiency—which obtains at a given capacity depends upon the interrelation of a number of variable factors of operation. It is essential that these factors be systematically conceived, and that in a given case their relative importance be known.

It is evident that the factors that govern combustion likewise largely govern the heat transmission of the boiler by the regulation of temperature and volume of gas. Therefore, in the end the performance of the entire boiler unit may be expressed in terms of a number of factors over which the fireman either does or should exercise control. Boiler efficiency is taken as the ratio of heat absorbed to the heat available for absorption. Furnace efficiency is defined as the ratio of heat available for absorption by the boiler to the heat in the coal.

The most important methods of firing coal employ the chain-grate and the underfeed and overfeed stokers. In each of these the time of transit of coal over the grate surface increases with decrease of load, and is not subject to independent regulation; also it is impossible to regulate independently the amount and admixture of air. The factors of air supply are controlled by the draft (pressure) and by the condition of the fuel bed. These several inflexibilities are inherent in the present status of the art. They are serious disadvantages which may be reduced.

Since regulation of the time element by regulation of the active area of grate surface seems to be impracticable, the problem of furnace operation becomes simply one of the air supply—not merely over the fuel bed as a whole, but in its several parts separately. That flexibility of air supply will to some extent compensate for inflexibility in time of transit of the fuel over the grate may be illustrated by any of the underfeed gravity stokers. The grate area of these stokers has been proportioned to give the proper time element for rated capacity. For example, take the case of the stoker used by the Cleveland Railway Co. When the capacity is increased, the air supply on the lower, or coking, grate cannot be increased enough to burn the coal as fast as it is received from the upper grate. The result is a piling up of coke and ash on the dump and extension grates, causing not only a large loss from carbon monoxide and coke to the ashpit, but perhaps serious clinker difficulties. A variable grate surface would obviate this trouble. It could, however, be largely mitigated by flexible and independent air control for this section of the fuel bed.

*Abstract of a paper presented at the spring meeting of the American Society of Mechanical Engineers, Cincinnati, Ohio, May, 1917.

The effect of fuel-bed thickness upon furnace efficiency is most marked for the light loads and least marked for the heavy loads. With a thin fuel bed a drop in efficiency characterizes heavy overloading. With heavy fuel beds the reverse is true. The explanation of all this lies primarily in the air supply and distribution.

There is an insufficiency of air for all loads in the case of the heavy fuel bed. Obviously, at light loads the thick bed shuts out the air most effectively. However, the key to these peculiar characteristics is to be found in the air supply to the lower extension and dump grates. Quite regardless of the fuel-bed thickness, overloading is accompanied by a piling up of unburned coke on these grates. The grates are

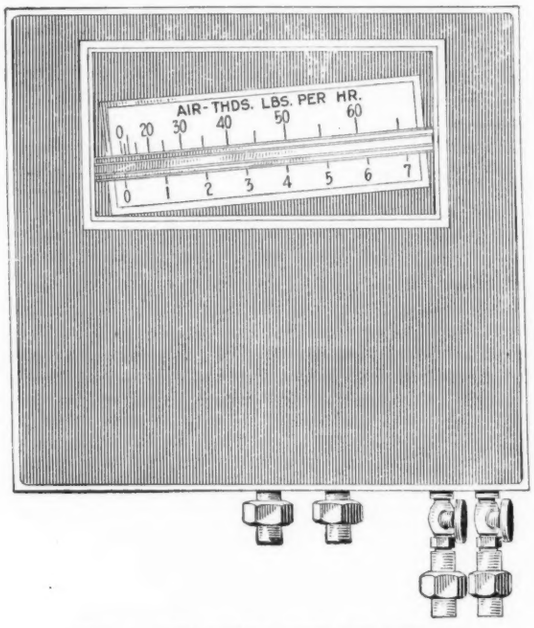


FIG. 1. MEASURES THE AIR SUPPLY

designed for rated load, and for this load the air supply is sufficient. The extension grates are supplied with air from a chamber opening through slide valves into the main-grate air boxes. Therefore any regulation of the main air supply affects proportionately the extension-grate air supply.

The stoker also depends to some extent on the air drawn up through the dump grates by the draft in the furnace. When the boiler is overloaded, it becomes necessary to increase proportionately the combustion rate and therefore the air supply on all sections of the grate surface. This applies just as much to the extension and dump grates as to the main grate. However, owing to both an insufficient and an almost inflexible air supply on these lower grates, combustible is delivered from the upper, or main, grate much faster than it can be burned on the lower grate. The piling up of ash and combustible rapidly makes worse the insufficiency of air. The losses from CO and the combustible to the ashpit increase excessively, and the net results are low efficiency and a tendency to the formation of clinker. Almost all the CO is formed on these lower grates. The CO begins at a low value just after feeding, and increases as the piling up of combustible increases.

With a chain grate the thickness of fuel bed may be readily measured and adjusted. Its condition is for the most part uniform over the whole grate. The draft in the combustion chamber constitutes the pressure drop through the fuel bed. Thus the chain grate readily lends itself to this system. It is therefore a simple matter to determine by tests the relation of furnace efficiency and capacity to the operating variables. In fact, the limits of expedient and efficient operation with a chain grate are not only narrow but readily apparent. This is a salient feature of this type of stoker. The forced-draft underfeed stoker is by no means so simple, and intelligent control is not only effective but essential. In this case the thickness of fire beds cannot be directly measured nor is its uniformity so much a matter of course.

The point of primary importance is the amount of air pushed through the fuel bed and the intimacy with which it is mixed with the volatile matter forming in the lower layers of green coal and in the coke of the upper layers. Roughly, this intimacy increases with the resistance to the flow. The pressure necessary to force a certain quantity of air through a fuel bed is both a simple and an effective indication of the mean condition and thickness of the fuel bed. In stokers of sufficient size to warrant the use of two air ducts, it is necessary to duplicate the air-measuring apparatus.

Of the instruments used by the writer in obtaining the results presented here, the apparatus for directly measuring the air supply, Fig. 1, merits perhaps a brief statement. It is quite possible, even where conditions are extremely unfavorable, to apply the pitot tube with close accuracy for measuring the air supply for forced-draft furnaces, and obtain at least excellent relative results. The manometer used in connection with the pitot tube may be placed at a distance from the air duct along with the other boiler instruments, without impairing its accuracy. When two manometers are necessary because of two air ducts, the sloping tubes may be placed side by side and readings taken from a single scale. The only time that the liquid levels will not be side by side will be when the fuel bed is not uniform in its resistance to air flow, a condition requiring immediate attention from the fireman. For example, a hole in the fuel bed will cause a marked difference in the two manometer levels.

Another principle may be employed in connection with the form of air meter described. The pitot-tube manometer shows deflections increasing as the square of the air velocities. Similarly, neglecting the relatively small amount of gas formed from the burning coal, the pressure drop through the fuel bed varies as the square of the air velocities. Therefore, as shown in Fig. 2, the relation between this pressure drop and the manometer deflection is a direct proportion. Utilizing this principle, another manometer tube similar to that shown in Fig. 1 may be placed inside the other tubes for the measurement of pressure drop. By using liquids of the proper relative densities or by introducing variation in the sectional area of the manometer, the level can be set to move up and down together for the proper thickness of fuel

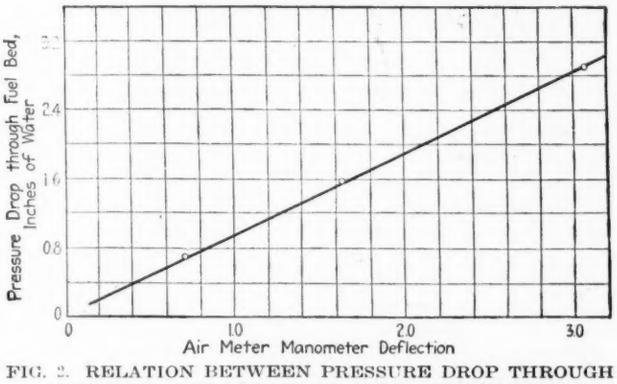


FIG. 2. RELATION BETWEEN PRESSURE DROP THROUGH FUEL BED AND AIR MANOMETER DEFLECTION, FUEL BED OF CONSTANT THICKNESS

beds; a ready indication of the amount of variation from the prescribed thickness is available. This last function is valuable in plants having peak loads of short duration. The fireman may gage the amount by which he is building up the fuel bed preparatory to the short overload. Thus a single instrument has been made to indicate all the fundamental conditions of combustion—amount of air, pressure drop through the fuel bed and thickness and uniformity of fuel bed.

It is evident that the factors governing furnace operation also determine the variables of boiler operation. The gas passing through the boiler is simply the air of combustion plus the weight of gasified coal, corrected if necessary for air infiltration. The temperatures in the boiler are governed

by the combustion conditions in the furnace. Therefore over-all efficiency and capacity are to be expressed simply in terms of furnace variables, thickness of fuel bed and pressure drop through the fuel bed. In the case presented here fuel-bed thickness is indicated by the weight of air and pressure drop, and these values therefore become the criteria of combined performance. The function of the flue temperature is merely a check upon the condition of the heating surface. The combustion-rate curves shown in Fig. 3 are of value only in assisting in the proper maintenance of the fuel bed. However, this information is not necessary since an insufficient fuel supply soon disturbs the prescribed relation between air and pressure drop. Reference to the data shows very little variation in the character of coal used in the tests, the results of which have been represented. This condition is indispensable under such a system of testing and can be attained easily by using a given coal. Once the desired relations have been established for an average and uniform grade of coal, the value of the results is not impaired by reasonable variation from such grades. Boiler performance will change from the interrelation of variables over which the fireman exercises control, but should not change appreciably. It would be only a radical variation in size or quality of coal that would necessitate a change in fuel-bed thickness to maintain maximum efficiency. The real objective is the best performance for each load for the grade of coal available. More than this can be claimed by no system of operation or class of design.

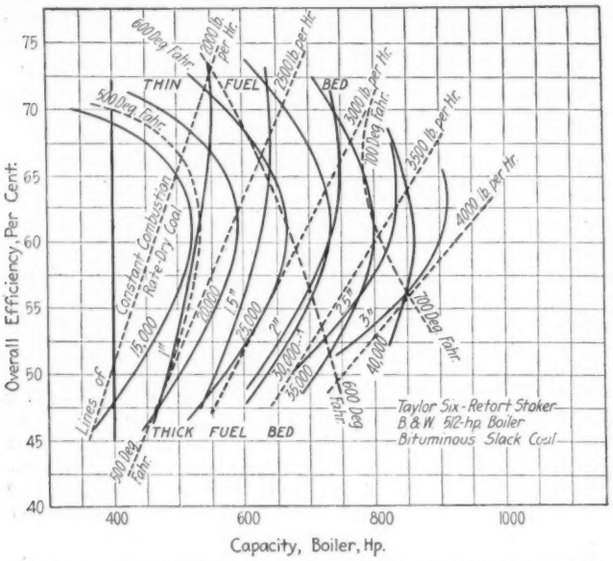


FIG. 3. OPERATION CHART, COMBINED BOILER UNIT

The combined boiler-unit operation chart, Fig. 1, brings out the essential importance of the variable factors that have been selected as determining performance. It supplies the information whereby the fireman may operate with maximum efficiency for each different load. It establishes the relation between efficiency and economy by which economic policy of the boiler room may be rationally planned. Lastly, a study of the chart and the reason for its characteristics becomes a sound basis of improvement in design.

Heating and Ventilating Engineers Meet at Chicago

From July 18 to 20 inclusive the American Society of Heating and Ventilating Engineers held its semi-annual meeting at the Hotel La Salle, Chicago. This is the fifth time the society has visited Chicago and the second time that it has been entertained under the auspices of the Illinois Chapter, which was organized Dec. 3, 1906, and is the oldest chapter of the organization.

Essentially the convention was a "preparedness" meeting. Through the agency of a committee recently appointed, the society is now in active coöperation with the Government.

The first session opened Wednesday morning with a few words of welcome by F. W. Powers, president of the Illinois Chapter, and a response by H. G. Issertell. In his presidential address J. I. Lyle spoke of the work of the society's committees in the heating and ventilation of submarines and battleships and the 16 huge cantonments, etc. During the process of manufacture of shrapnel shells it appears that careful air conditioning is required. Reports of chapters and standing committees followed.

The Research Bureau Committee outlined a number of possibilities under which a research laboratory might be established. The committee was continued to report at the annual meeting.

John S. Hale, chairman of the Committee on Engineering Coöperation, advised that the action of the society be extremely conservative, owing to the vagueness of the plans for coöperation. There would be plenty of time to consult other national societies and to discuss the question at the annual meeting before the next meeting on coöperation in March.

Prof. John R. Allen stated that the Committee on Standard Methods for Testing Radiators was not ready to report. They had developed a method of testing radiators by electricity, much simpler and more reliable than the steam method. Details will be given out later. The Committee on Testing Air Washers had found the methods hitherto used inaccurate. The quantitative method of determining dust content by means of the Hill dust counter was favored. This device was described. The Chicago Commission of Ventilation had found it very good, results being more reliable than obtained by other methods.

F. I. Cooper, chairman of the Schoolhouse Standards Committee, advised selection from standards used by architects and selections from what the school authorities generally did, so that schoolhouse planning could be standardized and reduced to a science. Standard forms and measurements would permit comparisons as to cost and requirements of classroom units, assembly rooms and toilets.

In the society there has been an active movement toward coöperation with the National District Heating Association. It was recognized that there was no need of conducting independent investigations on technical research. Discussions on rates and other matters relating to business were not of interest, but there was much on which the two societies could coöperate. It was voted to hold a joint meeting next summer, and committees of both societies were to compare notes so that there would be no conflict in the program. The National District Heating Association will meet early in the week, disposing of matters of particular interest to themselves, and then join with the American Society in the discussion of topics of common interest.

In order not to conflict with the annual convention of the American Society of Civil Engineers, it was proposed to change the annual meeting from the third to the fourth week of January. The method of changing the time of meeting without violating the constitution and the fixing of the exact date on which the convention will be held was left to the discretion of the council. A paper by F. E. McCreary on the hot-water heating system of the new plant of the Crane Co. ended the session. This plant was described in the Sept. 12 and 19, 1916, issues of *Power*.

The military session Wednesday afternoon was of intense interest. Capt. O. N. Solbert, instructor at West Point in civil and military engineering, spoke of the duties of the engineer in war and the equal importance of the engineer's work at home. In modern warfare the army plays a comparatively small part. That is, the efficiency of his work

depends upon the ammunition makers, the transport system, and in fact all supplies that must be sent to the front. Although the pomp and glory are missing, the engineer who has anything to do with making or sending supplies to the army is just as important a cog in the machine as the man on the firing line. Captain Solbert pointed out that the engineer for the army must be a jack of all trades who could readily adapt himself to different kinds of work, size up the situation quickly and act at once. In war the expense of engineering work did not count—time was the big element. To give some idea of the vast amount of material required by the army, the speaker enumerated the following as needed for one mile of front: 900 miles of barbed wire, 6¼ million sand bags, 12,000 small picks, 36,000 sq.ft. of corrugated iron, 1¼ million feet of lumber. All this in addition to immense quantities of ammunition, food and other general supplies. He laid particular emphasis on the importance of the internal-combustion engine. It has been one of the greatest factors in this war, making possible motor trucks for transportation, which speeded up the movement of troops and supplies, changed warfare through the airplane and made possible the submarine. The organization of a division, the smallest unit that can fight independently and is complete in itself, was enumerated, and the duties of the regiment of engineers accompanying it were given in detail.

Lieut. Col. T. E. Powell, D. S. O., Canadian Engineers, was the next speaker, his topic being sanitation, water-supply, heating and ventilation at the front. He outlined the primitive methods employed and spoke of the difficulties in getting the proper material for the work. Starting with division and brigade headquarters, he gave some idea of the type of buildings occupied and how they were heated and ventilated, following through on the same lines to the trenches and quarters occupied by the troops. In his opinion there was ample room for improvement in the field to which the society was devoted and the ingenuity of engineers of the American contingent would be tested to the limit. Anecdotes from his experience at the front were received and questions asked on different phases of the war and the health of the troops in training camps.

Poor Ventilation Detrimental to Health

W. J. Mauer followed with a paper on "Ventilation of Barracks." He spoke of the death rate from tuberculosis in the French army, due partly to the lack of ventilation and the housing of large bodies of men together. Specifications for one-story and two-story barracks were then presented, and the general arrangement, the amount of window area and the changes of air per hour given. The large barracks being built at Fort Sheridan and Rockford were mentioned, and reference was made to those at the Great Lakes Training Station. Although stoves were contemplated for heating, steam heat, in his opinion, would be much better, steam being supplied from a central plant. A temperature of 45 to 50 deg. was to be maintained in the barracks except when the outside temperature reached 10 deg. below zero, when the temperature within should be maintained at 40 degrees.

In the discussion Dr. Evans condemned these barracks, which were designed to hold 80 troops and were to be heated by four stoves. It had been the experience of the French and English authorities that large bodies of men in one room tended to propagate measles, cerebro-spinal meningitis, pneumonia and other contagious diseases. The experience at the Great Lakes Naval Training School last winter should not be overlooked. If the barracks now being prepared at Rockford, Fort Sheridan and other points were occupied next winter, the doctor predicted disaster. Under the conditions it is very easy for any of the diseases mentioned to develop, and with so many men together the contagion would spread rapidly. A committee was appointed to investigate and at the close of the convention turned in a resolution urging the Government to alter the design of these barracks, which in their opinion were neither sanitary nor healthful. A telegram to this effect was dispatched to the Secretary of War with the statement that the society stood ready to submit recommendations upon request.

"Notes on the Testing of Heating and Ventilating Equipment," by Dwight D. Kimball, J. Irvine Lyle and Arthur K. Ohmes, was the next paper presented. The authors outlined general methods of testing heating and ventilating equipment, selecting the best instruments to use in each particular case and outlined the precautions to be observed to insure accuracy. A second part of the paper dealt with the mechanics of heating and ventilation, taking up heating and ventilating equipment, methods of humidifying, direct and indirect cooling, dust and fumes removal. It was the authors' hope that the paper might lead to the creation of a code for standard testing methods throughout the country. In the present paper it was recognized that a good start had been made, and to keep the work up to date a standing committee of five on Standard Instruments and Methods of Testing was appointed.

Tests of Flow of Water in Pipes Described

In a paper on the "Friction of Water in Iron Pipes and Elbows," F. E. Giesecke presented results of tests on butt-welded black steel pipe conducted at the University of Texas. The tests were made on sizes from ½- to 3-in. diameter and at different velocities of flow. The effect of galvanizing and of incrustation on the friction had been determined, and other experiments showed that the friction decreased as the temperature of the water increased. The friction of elbows was also determined and expressed in equivalent lineal feet of pipe.

On Thursday morning an excursion was made through the Corwith plant of the Crane Co., which had been described earlier by Mr. McCreary. The afternoon was devoted to the fruit- and vegetable-drying session, the introductory speaker being H. C. Gore, of the Department of Agriculture.

A paper on "Dehydrating Fruits and Vegetables," by Fred R. Still, indicated what might be done in this line. Other papers of the session were: "Preservation of Food Products by Drying," by G. R. Shadwell; "Drying of Fruits and Vegetables," by Walter M. Schwartz; "Drying Money," by H. C. Russell; and the "Mechanical Curing of Alfalfa," by E. M. Bassler.

"A Study in Air Measurements and Air Flow," by Arthur K. Ohmes, the first paper Friday morning, gave the results of tests to determine the amount of air passing through rounded and square channels under slight pressure differences. Comparison of the test results with the theoretical air movement through these channels showed wide discrepancies. It would appear that more of this work should be done, as coefficients of resistance at our disposal are hardly sufficient to determine the flow of air in the most ordinary duct system, and even this with no scientific accuracy.

Coal Situation Discussed

Dr. F. C. Honnold, who is a member of the advisory committee on coal production and distribution of the Illinois State Council of Defense, spoke on the coal situation. He reviewed the period of the last two years, starting with the first war orders and following the increasing demands for coal as the industries speeded up and required an ever-increasing amount of fuel. The speaker mentioned the embargo which had checked the flow of coal and the substantial help afforded by the pooling methods adopted at lower lake ports. In his opinion Illinois was the strategical state for supplying the West and would be the pillar of hope in the present great emergency. In the past year 60 per cent. of the annual output had been handled between the months of October and February. In April, May and June of the present year Illinois showed an increase of 80 per cent. in coal production, the states of the Northwest an increase of 70 per cent., and the Southwestern States an increase of 40 per cent. over the same months of last year. These percentages meant an increase of 12,000,000 tons of coal. A full car supply would have permitted the shipment of an excess of 18,000,000 tons. Only 10 weeks remained before domestic and other demands would require the entire output. The situation now faced was purely a matter of transportation. Dr. Honnold mentioned the voluntary agreement of the operators on the price set by the Government. No coal for the Government or for large shipments

to industrial concerns would be sold above the fixed price, but there was little hope for the small consumer to get coal at these low prices. The cost of production had increased from 35 to 75c. per ton and the sporadic working hours due to the inadequate supply of cars added to the expense of mining. Copies of a report presented by his committee to the Illinois State Council of Defense containing a long list of suggestions which, if followed, would improve the coal situation, were available at the meeting.

D. L. Gaskill made a stirring appeal for coöperation between the American Society of Heating and Ventilating Engineers and the National District Heating Association. While the fields of the two societies were distinctive and there was need for each association, there was a certain amount of overlapping. In the field common to both of them there should be coöperation. His suggestion was to have standing committees, one for each association on the same subject; the chairman of each could lay out lines to be followed by his respective committee so that each would get proper credit for the work done and there would be no duplication. The two committees could then present a joint report. The National District Heating Association had passed favorably upon the matter at the Detroit meeting, and the present convention of the American Society of Heating and Ventilating Engineers backed up the action taken earlier by the council to the effect that there would be a joint meeting of the two associations next summer.

Dr. E. V. Hill, of Chicago, presented a most interesting paper on "Ventilation Standards and the Synthetic Air Chart." With the latter the relative humidity can be determined from test data without reference to other tables or charts, desirable combinations of temperature, relative humidity and air motion to maintain comfort are easily determined, and the relative importance of the various factors influencing the air condition is indicated. The chart affords a convenient method for recording test data and is of great value as a comparative standard in ventilation-test work. The latter part of George T. Palmer's paper, entitled "Are Schoolrooms Drier Than Deserts?" was then read and the two papers were discussed simultaneously.

Action of Thermostatic Values Recorded

F. A. DeBoos presented in abstract his paper on the "Operation of Diaphragm Radiator Valves Thermostatically Controlled." The author had conducted a number of tests to determine the approximate number of times diaphragm radiator valves would be opened and closed by a thermostat, to determine approximately the time steam would be automatically shut off the radiator and to find how closely the room temperature would be maintained by the thermostat. A month's test made on a certain radiator in an office building showed that the valve was closed on an average 63 per cent. of the time. Different types of valves were employed and some interesting data obtained. The following papers were read by title: "Mine Ventilation," by J. J. Walsh; "Warm-Air Furnace Heating," by I. F. Grumbein; and the "Use of Refrigeration in Air Conditioning," by L. Nusbaum.

As it was desired to close the convention Friday instead of holding a session Saturday morning, as originally planned, the final paper on the program, "Measurements of Low-Pressure Steam Used for Heating," by J. E. Emswiler, was held over for presentation at the annual meeting. The final action of the convention was to vote the council a patriotic fund to help members who were personally unable to stand the expense to do expert work for the Government. If the treasury were depleted in this work, a subscription fund was to be started.

It was the consensus of opinion that the entertainment during the convention had been the most enjoyable and elaborate in the history of the society. The committee responsible was highly commended and given a hearty vote of thanks. The entertainment consisted of a dinner and dance at the Chicago Yacht Club Wednesday evening, an excursion to the Corwith plant of the Crane Co. Thursday morning, a dinner and garden party at the Bismarck Gardens Thursday evening and a golf tournament at the Flossmoor Country Club Friday afternoon. In addition sightseeing trips were provided for the ladies, of whom there was a goodly number in attendance.

Early Canadian Boilers*

In the early days—that is, sixty or seventy years ago—the type of boilers generally in use in Ontario was externally fired, with three to five flues 8 to 10 in. diameter. The diameter of these boilers seldom exceeded 54 in., but what they lacked in girth they made up in length, as 20 to 25 ft. was no uncommon stretch for those old stagers. The seams were all of single-riveted lap construction, and the plates ranged in thickness from ¼ to ⅜ in. The shell rings and also the tube rings were telescoped one into the other like stovepiping. They were very strong on domes at that time, and I believe a boilermaker did not think he was building a boiler at all unless he had a huge dome on the outfit. Most of those were cast iron, and some manufacturers adhered to this style of dome until as late as 1890. With this exception wrought iron was the material almost exclusively used in boiler construction. As a rule the plates were short and measured about 4 ft. 6 in. square and were soft and ductile, but blisters or laminations were not infrequently met with, which caused considerable loss and inconvenience. Another imperfection was spongy parts, generally due to imperfect puddling, but notwithstanding these defects the old iron boilers gave good service, and many are still in use after thirty or forty years of general wear and tear. The steam pressures carried were low, and forty to fifty pounds was considered high pressure.

Our plate rolls originally were made of wood and were operated by hand. This of course was only made possible by the size and thickness of the sheets used at that time. Punching was done by hand with a screw or bear punch, and sometimes as many as four men were employed at a time to pull on the punch lever. All holes were punched full size, and those that did not come fair enough were usually persuaded into alignment by the gentle assistance of drifts and sledges. Sometimes a taper reamer was used, but this was the exception rather than the rule, and any holes that could not be reached with the punch were cut with a round-nosed chisel. The head plates were flanged with large wooden mauls over cast-iron flange blocks of the required size. It was customary to make the heads a little undersize so that they could be drawn out gradually to the exact diameter. Heads were dished in a very crude manner by digging a hole in the ground somewhat resembling the desired curvature of the head. The circular plate was then heated and beaten down into this hole with wooden mallets, the finishing process being accomplished by flatteners and sledge hammers. It sometimes happened in the case of heads dished to a deep camber that the work could not be done in this way, and a large cast-iron ball was used. This ball was hoisted a certain distance, then dropped on the red-hot plate in much the same way as a piledriver. We must not, however, despise the useful work of our predecessors, for they built many good boilers in those good old days.

We have a large number of boilers in Ontario, constructed before the present boiler law came into force, which were built in a thorough, workmanlike manner. We also have some that are not so good, and they were not all built in Canada; but since the enactment of the present law we are quite satisfied that better boilers are being turned out and the purchaser is well safeguarded as far as workmanship and material are concerned.

*From a talk by D. M. Medcalf, chief boiler inspector, Toronto, Canada, before the American Boiler Makers' Association, at Pittsburgh.

Necessity of Conserving Oil Supply

Oil shortage may force Western railroads to electrify in order to conserve the scant supply of fuel oil available to meet the urgent demand for fuel for airplanes, tractors and naval vessels for war purposes. The Southern Pacific alone consumes about 44,000 bbl. per day. The suggestion has been urged on the Administration at Washington that all oil-burning plants be discontinued either by electrification from hydro-electric sources or the substitution of other fuel wherever feasible, during the present emergency at least.

New Publications

STEAM BOILERS. By H. de B. Parsons. Longmans, Green & Co., New York. Cloth; 6 x 9 in.; 377 pages; 157 illustrations. Price, $4 net.

The first edition of this book appeared in 1903, and the edition now being reviewed is the 1917. Although the author does not say so in his preface, the book aims to be general. The first chapter is devoted to physical properties, including solids, fluids, gases, and definitions of terms used in the thermodynamics of steam boilers. Chapter 2, which deals with combustion, is on the whole very good, although there are some exceptions which the present reviewer takes. Regarding what takes place when a fresh charge of coal is thrown upon the fire (page 14), the author speaks about the charge of fuel becoming a great absorbent of heat, saying: "This apparent loss of heat is utilized in volatilizing the bituminous portion and is a very cooling process, due to the change of sensible into latent heat. While this generation of the gases is taking place, the carbonaceous part remains black or at a low temperature, awaiting the proper time for it to burn." It is not so much that the carbonaceous part of the fuel remains at a low temperature. This material is then at a temperature too low for its active or rapid combustion.

In speaking of the steam boiler as productive of smoke, the author, on the same page (15), says: "Of all the different kinds of furnaces designed for various purposes, the most persistent smoker is that of the steam boiler. The reason is obvious, as there are no hot walls to radiate back the heat and thus aid combustion." In the far greater number of boilers, especially those used on land, combustion of the fuel takes place within a firebrick furnace. Further, the very reason for using such high boiler settings as 48 to 72 in. for horizontal return-tubular boilers, and from 8 to 12 ft. for modern water-tube boiler installations, is to provide a refractory brick wall surface that it may radiate back into the furnace and through the gas particles evolved during combustion the necessary heat for the completion of their combustion, provided, of course, there is a proper quantity of air admitted and that this air is properly mixed with the gases.

Nothing is said about ash fusion, other than to merely mention clinkering in a paragraph or two. With the ever-increasing use of stokers and high combustion rates, this is a subject important enough to go in any book dealing with boilers generally.

On page 40 occurs the following: "It is not within the scope of this work to treat this subject (chemical composition of coal) fully, but reference should be made to works on the subject. Kent's 'Handbook for Mechanical Engineers' gives a number of analyses of many different kinds of coal." The next time the author gives Mr. Kent's book in quotation marks, he should say "Pocketbook," not "Handbook." It would have been worth while to give as a reference Bureau of Mines Bulletins No. 22 Parts 1 and 2, dealing with "Analyses of Coals." Mr. Kent's latest table of coal analyses does not appear in his pocketbook but does appear in his "Steam Boiler Economy," second edition, beginning page 63, and this table, Mr. Kent's best, is from the Bureau of Mines bulletins just mentioned, as Mr. Kent credits on page 58 of "Steam Boiler Economy."

The use of powdered coal, either for stationary or locomotive practice, is not mentioned.

Relative to moisture in the coal as it affects the heat available for transmission into the boiler water, the author says on page 42: "When moisture is present, as in nearly every case, then the total heat of combustion available is found by subtracting from the above results the heat necessary to evaporate this moisture. This may be done by the following formula: Heat units required to evaporate moisture in one pound of coal equals percentage of moisture divided by 100, multiplied by

$$[(212 - Ta) + 970 + 0.48 (Tf - 212)]$$

in which Ta denotes temperature of air in boiler room; Tf denotes temperature of furnace gases; 970 denotes latent heat of evaporation of water; 0.48 equals specific heat of steam under constant pressure."

Whether or not the formula is correct depends on what one interprets as the meaning of "available." The logical interpretation is, of course, that it is the difference, for unit volume of gas, between the temperature in the furnace and the temperature of the gases leaving the boiler. The author makes the mistake of taking the temperature of the furnace gases instead of the temperature of the flue gases.

Chapter 5, from pages 62 to 124, is devoted to descriptions of types of boilers and is very commendable. The chapters on materials and boiler details, and boiler fittings are, on the whole, commendable. The Boiler Code of the American Society of Mechanical Engineers is widely quoted.

We hope that in the next printing of this edition the author will see to it that the first sentence of the third paragraph on page 293 is revised. In speaking of the Reilly evaporator in the sentence, he says that it is made by the James Reilly Repair and Supply Co., of New York. This evaporator has been made by the Griscom-Russell Co. for the last seven years.

Chapter 10, which treats of mechanical stokers, is indeed disappointing. But five pages are devoted to this subject, which within recent years has become so important in boiler-room work. There are many other parts of the book that might have been omitted in order to treat of this subject without making the book too bulky. The chapter is not even an adequate description of what may be considered representative modern stokers. The old design of Roney stoker is shown, though few are made now.

On page 296 is shown "the American Mechanical Stoker." This type became obsolete more than three years ago.

On page 297 the statement is made that "the best stokers are those which are least complicated, have the fewest parts to get out of order and have the details properly worked out in accordance with good mechanical principles." We are sure that one of the prominent stoker manufacturers, and especially one that manufactures the stoker with movable parts directly under the fire-bed, will properly take serious objection to this statement. Toward the bottom of the same page the statement is made that "chain grates are suitable for poor grades of noncoking coals and free-burning coals high in volatile matter." The chain-grate stoker is particularly adapted to coals that are high in ash, not necessarily high in volatile matter, except that many coals high in volatile matter are also high in ash. Under the heading of "Objections to Stokers" the reader will find, "and lack of facility to force the fire in response to sudden demand." This is one of the chief claims of most stoker manufacturers, and the statement is decidedly wrong. Some of the most widely used stokers, particularly those of the underfeed type, not only are not shown in the book, but they are not mentioned by name or even by inference, although the oldest types of stokers are given prominence.

Considering the little that has been added to the book, we can see no reason for this latest edition, despite the author's claim in his preface that "in preparing this fifth edition, many changes have been made in the text in order to improve the book and to bring the subject matter up to date. These changes have practically made it a new work."

Engineering Affairs

The Western Society of Engineers' board of directors held a meeting on July 9, and unanimously decided that the society present to the First Regiment, Illinois Engineers, the national and regimental colors. This regiment is now and will continue to be a permanent unit of the Illinois National Guard. It has been organized and recruited by the Citizens' Unit, and includes many members of the society.

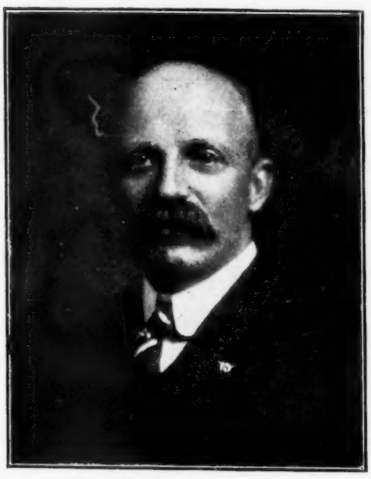
The Oregon Society of Engineers held its last meeting on June 28. There will be no meetings during the months of July and August. The past spring has been one of marked activities and of rapid growth. A change in the constitution permits the formation of local chapters in the smaller districts of the state, to coöperate with the parent organization and furnish papers for the monthly journal. A systematic series of lectures and published reports by the society have aroused considerable discussion. **The society will** soon conduct an engineering cash prize story contest.

The Engineer's Blue Club, of Jersey City, N. J., held its eleventh annual outing and games at Midland Park, Staten Island, on Sunday, July 22. The attendance was the largest in the history of the organization. Many prominent and several out-of-town engineers were present, the New England States Association being represented by Harry Markham. Outdoor sports of all kinds were indulged in, including a game of baseball between the Blue Club and the Evansville Nine, the latter winning by the score of 16 to 3. **Frank Tuthill** was captain of the winning team and Bert Self and Joe McKenna were the umpires. There were prizes for the winners of each event. The affair was under the management of John J. Callahan.

Progress Council No. 12, of the Universal Craftsmen Council of Engineers, held an open meeting on Wednesday, July 11, at its rooms, 248 Market St., Newark, N. J. The General Electric Co. gave a motion-picture description of the development of transportation from the early days up to the present time, and showing the manufacture of the electric locomotive. These pictures were particularly commendable because of their completeness. The Public Utilities Commission gave three reels of pictures entitled "Safety First," illustrating the dangers of everyday travel and strongly recommending "Stop, Look and Listen" to the careless pedestrian. After the pictures Brother DeWitt Paxton and Jack Armour, of "Power," entertained. The educational committee, of which J. T. Lawson is chairman, was responsible for the pleasant evening.

Obituary

William G. Bee, vice president and general sales manager of the Edison Storage Battery Co., died at his home in Orange, N. J., on July 11, after an illness of two years. He was born in Hartford, Conn., 49 years ago. At an early age he enlisted in the United States Navy, and upon receiving an honorable discharge after four years' service, he returned to Hartford and associated himself with the Pope Hartford Bicycle Co., which later became the Electric Vehicle Co. In this way he became one of the pioneers of the electric-vehicle industry, and it was he who drove the first automobile in the streets of Newport, R. I. In 1903 he became associated with Thomas A. Edison at Glen Ridge. When the Edison Storage Battery Co. was organized, he became its general sales manager and was later elected vice president. He was a thirty-second degree Mason and held membership in the National Electric Light Association, the Electric Vehicle Association, the Motor Truck Club of New York, the Automobile Club of America, American Institute of Electrical Engineers, Society of Automobile Engineers, Jovian and many other business and fraternal organizations. He is survived by his widow and a daughter.



W. G. BEE

Miscellaneous News

The Council of the City of Scranton has adopted the A. S. M. E. Boiler Code, and it is now a law in that city.

The Syracuse (Ind.) Power and Light Co.'s plant was sold recently to the Hawks Electric Co., of Goshen, Ind., through the Warsaw Investment Co. for $70,000 cash. The plant furnishes light and power for Syracuse, Benton, Milford and other points in the vicinity of Wawasee Lake.

The City of Orlando, Fla., is considering the erection of its own water plant to be operated by the city authorities. A committee of three has been appointed to employ a competent engineer to make a survey and ascertain the probable cost of such a plant.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	July 28, 1917	One Year Ago	July 28, 1917	One Year Ago
Buckwheat ..	$4.50—4.65	$2.05—3.20	$5.75—6.00	$3.25—3.50
Rice	3.90—4.10	2.50—2.65	5.15—5.35	2.70—2.95
Boiler	3.65—3.90	.....	4.90—5.05	.....
Barley	3.40—3.55	2.20—2.35	4.65—4.80	2.35—2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	July 28, 1917	One Year Ago	July 28, 1917	One Year Ago
Clearfields ...	$3.64—4.50	$1.10—1.60	$8.35—8.60	$4.25—5.00
Cambrias and Somersets...	3.64—4.75	1.35—1.75	8.50—8.75	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $5.14—6.60, as compared with $2.85—2.90 a year ago; on cars Boston price is $9.25—9.50.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	July 28, 1917	One Year Ago	July 28, 1917	One Year Ago
Buckwheat ..	$4.00—4.15	$2.75	$4.50—4.75	$2.55—2.75
Rice	3.40—3.60	2.25	3.50—3.75	2.00—2.20
Barley	2.90—3.10	1.75	2.25—2.50	1.75—1.95

BITUMINOUS

Bituminous quotations at Tidewater are $7—7.50 alongside for bunker coal and $3 net f.o.b. mine. These quotations apply on all grades and are in accordance with the Government maximum.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	July 28, 1917	One Year Ago	July 28, 1917	One Year Ago
Buckwheat ...	$2.90	$1.65	$3.80	$2.55
Rice	2.40	1.00	3.40	....
Boiler	2.20	.90	3.30	1.80
Barley	1.90	.75	2.15	....

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	July 28, 1917	One Year Ago
Slack	$3.00—3.25	$0.95—1.00
Mine-run	3.00—3.25	1.35—1.45
¾-in.	3.50—3.75	1.45—1.55

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump ..	$3.25–3.50	$3.25–3.50	$3.25–3.50	$3.00–3.25	$3.25–3.50
Lump	3.50	3.50	3.75	3.25–3.50	3.50
Egg	3.50	3.50	3.75	3.25–3.50	3.50
Nut	3.50	3.50	.....	3.25–3.50	3.50
No. 1 nut....	3.50	3.50	.....	3.25–3.50	3.50
No. 2 nut....	3.50	3.50	.....	3.25	.....
No. 3 nut....	3.50	3.50	.....	.....	.....
No. 1 washed.	3.50	.....	.....	.....	.....
No. 2 washed.	3.50	.....	.....	.....	.....
Mine-run	2.75	2.75	3.25	2.50–2.75	2.75
Screenings	2.75	2.75	.....	2.50–2.75	2.75

Hocking lump, $3.75; splint lump, $3.75.

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	July 28, 1917	One Year Ago	July 28, 1917	One Year Ago	July 28, 1917	One Year Ago
6-in. lump..	$3.25	$1.50	$2.50	$1.35	$2.50	$1.10
2-in. lump..	3.25	1.35	2.25	1.20	2.25	.90
Steam egg...	3.25	1.35	2.25	1.20	2.25	.90
Mine-run ...	2.50	1.15	2.25	1.10	2.15	.85
No. 1 nut..	3.25	1.35	2.50	1.35	2.50	1.00
2-in. screen..	2.50	.85	2.25	.90	2.00	.85
No. 5 washed	2.50	.75	2.20	.75	2.00	.70

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3.50	Carbon Hill	$3.25—3.50
Big Seam	2.75—3.00	Cahaba	3.75—4.00
Black Creek	3.75—4.00		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Calif., Sonora—City election July 31 to vote on $45,000 bonds to install a municipal lighting system and power station; plans involve a complete system with underground lines.

Fla., Jacksonville—The City Commission plans to purchase a new alternator for the municipal electric-light plant. J. A. Parks, Clk.

Ga., Moultrie—The Moultrie Packing Co. plans to remodel and build an addition to its power plant.

Ill., Lincoln—The Lincoln Water and Light Co. has been taken over by the persons now operating the Logan County Gas Co. of this city. It is planned to enlarge the plant and extend the services in Lincoln and contiguous counties. E. MacDonald, Mgr.

Ky., Owingsville—The Owingsville electric-light plant has been taken over by J. M. Richards and E. V. Brother, who plan to build a new plant and install new equipment, the power to be a 75-hp. oil engine.

Mich., Grand Rapids—The Eastern Michigan Power Co. plans to build a plant on the west side of the canal. Estimated cost, $20,000. The company plans to purchase several thousand dollars' worth of machinery.

Mich., Monroe—The Detroit, Monroe & Toledo Short Line R.R. plans to build an addition to its power station and will also install additional generating units.

Neb., Beatrice—City plans to build an electric-light plant. About $50,000. A. J. Pethoud, City Engr.

Nev., Yerrington—The Kennedy Consolidated Mines Co. is having plans prepared for an electric-lighting plant to be built on its property.

N. Y., Oneida—The Chamber of Commerce is making investigations for establishing a municipal electric-light plant. J. M. Hutton, City Engr.

N. Y., Sherman—The Board of Trustees has applied to the Public Service Commission for permission to establish a municipal electric-light plant.

N. Y., Utica—The Savage Arms Corporation, Turner St., plan to build a power plant in connection with new additions to its plant.

N. C., Mockville—The City Commissioners plan to issue bonds to install an electric-light plant and water-works system.

N. C., Spencer—The Southern Ry. plans to operate its new local car-repair shops by electric power, with individual motor drive where required. The company also plans to build transformer station at the works. B. Herman, Washington, D. C., Ch. Engr. M. W.

N. C., Warsaw—City to issue $15,000 bonds for electric-light work.

Ohio, Cleveland—The Cleveland Electric Illuminating Co., 711 Cuyahoga Bldg., plans to build an electrical station at 720 East 70th St. Estimated cost, $100,000. J. Wolff and F. S. Lewis, Engrs.

Ohio, Cleveland—The Newburg & South Shore R.R., Western Reserve Bldg., plans to build a concrete and steel boiler house on East 71st St. Estimated cost, $20,000. H. L. Scheuler, Newburg, Cleveland P. O., Ch. Engr.

Penn., Lancaster—The Directors of the Lancaster General Hospital, 528 North Lime St., plan to install anew electric power station. Estimated cost, $15,000.

Penn., Philadelphia—The Board of Public Works is having plans prepared by P. H. Johnson, Land Title Bldg., for a new 1-story brick and steel plant, to be built at 34th and Pine Sts. G. S. Webster, City Engr.

Penn., Philadelphia—E. F. Houghton & Co., 240 West Somerset St., plan to build an addition to its power plant on American and Somerset Sts.

Penn., Philadelphia—The Philadelphia Rubber Works plans to build a new 1-story transformer station to its plant at 37th and Reed Sts.

Que., Sherbrooke—City voted $150,000 bonds to build an electric transmisison line from Weedon to Sherbrooke and to build a substation at Sherbrooke.

S. C., Greenville—The Southern Power Co. of Charlotte plans to build an electric transmission line to the army cantonment near Greenville. Estimated cost, $30,000. W. V. Trollinger, Greenville, Local Supt.

Tenn., Kingsport—The Kingsport Utilities Co., recently incorporated with $1,000,000 capital stock, plans to build a power plant with transmisison system and distributing lines to reach the neighboring sections. S. C. Hall, Pres.

Tex., Alvin—The Alvin Light and Ice Co., recently incorporated with $15,000 capital stock, plans to build an electric-light and ice plant. C. A. Leavens is a stockholder.

Tex., Beaumont—The Beaumont Shipbuilding and Dry Dock Co., recently organized, plans to build a shipbuilding plant on Island Park. Plans include a 25 x 40-ft. power house. C. O. Yoakum is Vice Pres. and Mgr.

Wash., Arlington—The Snohomish County Commissioners have granted a franchise to the Washington Coast Utilities Co. to build about 200 mi. of electric transmission lines through 8 townships in the north end of the county. The company will also supply electricity and water in the City of Arlington.

Wash., Tacoma—The Wheeler-Osgood Co. plans to build a steam-electric power plant. Estimated cost, $60,000.

W. Va., Hartford—The Mason Coal and Chemical Co., Union Bldg., Charleston, plans to build a new plant at Hartford. Plans include an electric power plant to furnish electricity for operating the works. The company will purchase equipment for the power house, including engines, boilers, etc.

Wis., Madison—The Pennsylvania Power Co. is having plans prepared by Mead & Seastone, Engrs., Madison, for a hydro-electric plant. Estimated cost, $500,000. J. W. Disbrow, Ellwood City, Penn., Supt.